HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

LONDON

Summary of main findings for London

In 2001 the PM_{10} annual daily mean (SD) measured in central London was 13.1 (5.6) µg/m^3, below the 1999/30/EC Directive limit value for 2010 (20 µg/m^3) and below that established for 2005 (40 µg/m^3). Nevertheless, it is still possible that reductions in PM_{10} may delay death in a small number of individuals.

For the summer months (April to September) of the same year, the mean (SD), P5 (5th percentile) and P95 of the maximum daily 8-hour moving average concentrations of ozone (O_3) were 47.1 (24.2), 11.2 and 88 µg/m^3 respectively. For O_3, a reduction of 10 µg/m^3 in the daily maximum 8-hour moving average concentrations during the summer months may delay up to 78.5 (95% CI: 43.1, 131.7) deaths per year in the general population assuming all other risk factors remain unchanged. The corresponding figures for cardiovascular and for respiratory diseases were 46.7 (22.3, 74.1) and 42.4 (27.8, 56.7). The impact of a similar reduction in ozone on hospital admissions is smaller and more imprecisely estimated - a reduction of 10 µg/m^3 in summer-time ozone concentrations may represent reduce the number of hospital admissions for respiratory diseases by 6.0 (-54.3, 72.4) in the adult population and by 47.2 (-18.9, 113.2) in the population aged over 64 years.

Infant mortality in Europe is quite low and consequently, the expected attributable number of deaths related to air pollution is also very low.

Summary of HIA of outdoor air pollution in London in ENHIS-1

Health outcome	**Population**	**Pollutant**	**Period**	**Mean type**	**RR (for 10 µg.m^3 increase)**	*References*	**Number of attributable cases by scenario[1]**	
Mortality							**Ozone: Reduction by 10 µg.m^3**	**PM10: Reduction by 5 µg/m^3**
Total mortality excluding external causes (ICD9 < 800 - ICD10 A00-R99)	All ages	O_3 8h max	Summer[2]	Daily	1.0031 (1.0017-1.0052)	Gryparis et al 2004	78.5 (43.1, 131.7)	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		46.7 (22.3, 74.1)	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		42.4 (27.8, 56.7)	
Total postneonatal mortality	1 month-1 year	Corrected PM_{10}[3]	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		4.4 (2.0, 6.8)
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.216 (1.102-1.342)			1.4 (0.7, 2.1)
Postneonatal Sudden Infant Death Syndrom Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		1.6 (0.9, 2.2)
Morbidity								
Emergency room visits for asthma (ICD-9 codes 493, ICD-10 codes J45, J46)	< 18 years	O_3 1h max	Year	Daily	1.0115 (1.0067-1.0163)	CARB 2004	not available	
Cough	< 18 years	Measured PM_{10}			1.0407 (1.0202-1.0511)	Ward and Ayres 2004		not available
Lower respiratory symptoms LRS	< 18 years	Measured PM_{10}			1.0407 (1.0202 -1.617)	Ward and Ayres 2004		not available
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	< 15 years	Measured PM_{10}			1.010 (0.998-1.021)	Anderson et al 2004		not available
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)		6.0 (-54.3, 72.4)	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		47.2 (-18.9, 113.2)	

[1] For ozone: absolute reduction by 10 µg/m^3. For PM_{10} absolute reduction by 5 µg/m^3.

[2] Definition of summer period : 01 April – 30 September

[3] PM_{10} reference papers for HIA on postneonatal mortality use gravimetric methods to measure PM_{10}. If the local air quality network uses automatic methods (TEOM or other) a correction factor is required to compensate for loss of volatile compounds: if available, a local correction factor recommended by the air quality network or, by default, the European factor 1.3.

Introduction

London lies within a roughly circular basin covering an area of approximately 1,600 Km^2. It lies at a latitude of 52 degrees north and enjoys a temperate maritime climate. The data used for this study are from 2001, both for health data (mortality and hospital admission statistics) and air pollution data sources.

This work has been carried out within the framework of work package WP5 on health impact assessment of ENHIS-1 project (www.enhis.net).

Sources of air pollution

Principal sources of air pollution were described in detail in the previous APHEIS city report (www.apheis.org). The most recent source data available for London are from year 2000. However these are unavailable for the city of London as a whole because of large spatial variations.

Exposure data

There is an extensive network of air pollution monitoring sites thoughout London and the UK. The pollutants monitored vary from monitoring station to monitoring station. The location of a station, in relation to its immediate surroundings, is classified as urban background, roadside, suburban etc. A single central site, classified as urban background and monitoring PM_{10} and O_3 has been used for this study (London Bloomsbury). Data availability and completeness as well as station classification are all factors in the choice of monitoring stations. All pollution data are for year 2001.

Daily indicators have been calculated as follows:

- PM_{10}: daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the stations.
- Ozone: the daily maximum 1-hour indicator has been calculated as the arithmetic mean of the 1-hour maximum of the stations. The daily maximum 8-hour moving average of each day have been calculated as the arithmetic mean of the maximum 8-hour moving averages of the stations for the summer period (1st April to 30th September)" .

The annual mean level (SD) of PM10 in London was 13.1(5.6) $\mu g/m^3$, and P5 and P95 of the daily mean values were, respectively, 6.9 $\mu g/m^3$ and 24.2 $\mu g/m^3$. The mean (SD), P5 and P95 of the daily maximum 8-hour moving average concentrations of summer-time O_3 were, respectively, 47.7 (20.7), 17.9 and 83.1 $\mu g/ m^3$, and those of the daily maximum 1-hour concentrations 47.1 (24.2), 11.2 and 88.0 µg/m3

Summary statistics for each pollutant measure are given in Table 1. Figures 1-3 show the frequency distribution for each pollutant measure in 2001.

Table 1. Descriptive statistics for ozone and PM_{10} levels in London in 2001

	O3 8h - summer	O3 1h max - year	PM10 - year
Number	178.0	353.0	362.0
Minimum	9.0	4.0	5.0
Percentile 5	17.9	11.2	6.9
Percentile 25	34.0	32.0	9.3
Median	46.0	46.0	12.0
Percentile 75	58.8	60.0	15.1
Percentile 95	83.1	88.0	24.2
Percentile 98	103.8	109.9	27.9
Maximum	125.0	150.0	45.7
Daily mean	47.7	47.1	13.1
standard error	20.7	24.2	5.6
% missing values	2.20%	3.29%	0.82%

Figure 1 Distribution of 8-hr summer time Ozone, London 2001

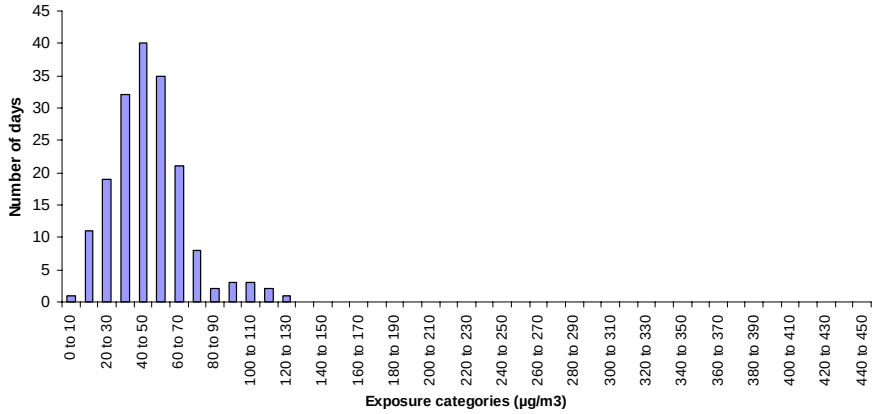


Figure 2 Distribution of 1-hr Ozone, London 2001

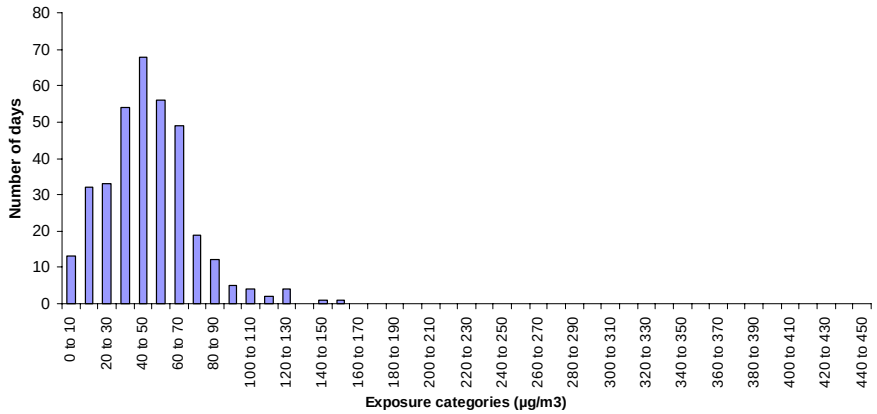
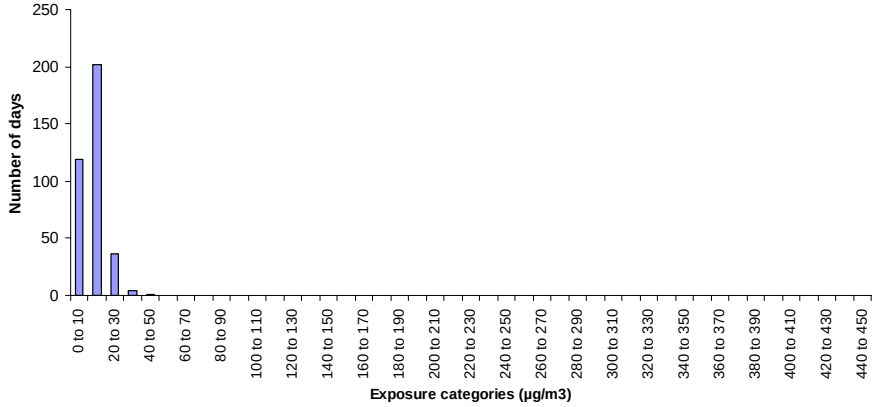


Figure 3 Distribution of PM_{10}, London 2001



Health data

The Office for National Statistics and Department of Health provide information on mortality and hospital admissions in England and Wales (Table 2). These data contain anonymous records giving cause of death or admission by ICD10 code together with age, location of residence and treatment. Data are collected subject to stringent quality assurance procedures. No routine data are readily available for emergency room visits or lower respiratory symptoms such as cough.

Table 2. Descriptive statistics for health outcomes in London, 2001

Health outcome	ICD9	ICD10	Annual deaths	Annual rate (per 100 000)	Daily mean (SD)	Daily rate (per 100 000)	Annual incidence rate (per 100 000)
POSTNEONATAL MORTALITY							
Total			191	200			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	16	17			
Sudden infant death syndrome *ICD9 798.0 – ICD10 R95*	798.0	R95	29	30			
GENERAL POPULATION MORTALITY							
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			144 (18)	2.0	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			58 (10)	0.8	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			22 (6)	0.3	
MORBIDITY							
Cough					not available		
Lower respiratory symptoms LRS					not available		
Emergency room visits for asthma - Age < 18 years *ICD9 493, ICD10 J45 J46*	493	J45-J46			not available		
Hospital respiratory admissions - Age < 15 years *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99					1229
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					251
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					2215

Health Impact Assessment

Methodology

The health impacts of air pollution (AP) have been calculated as the annual number of health events attributable to AP in the target population. Health impact assessment (HIA) can only be performed for those outcomes with sufficient evidence of causality. Once these have been determined, the next step is to find the best exposure-response functions (ERF) for each of the selected outcomes. Table 3 shows the result of a systematic review of the evidence carried out by the Bilbao Apheis team[1] for WP5 of ENHIS-1. This table summarizes the health outcomes and ERF deemed suitable for HIA according to the criteria established by WP5 with the advice of the air pollution experts of WP5[2].

Table 3. Health outcomes and Exposure-response functions (ERF) selected for health impact assessment

	OUTCOME	POLLUTANT	ERFs	ORIGINAL SOURCE
CHILDREN – PARTICLES				
	Total postneonatal mortality (1 month-1 year)	PM_{10} Annual Mean	RR=1.048 (1.022-1.075) ↑10µg/m^3	Lacasaña et al 2005
	Postneonatal respiratory mortality ICD9 460-519 ICD10 J00-J99	PM_{10} Annual Mean	RR=1.216 (1.102-1.342) ↑10µg/m^3	Lacasaña et al 2005
	Postneonatal Sudden Infant Death Syndrome (SIDS) mortality (normal birth weight ≥2500g) ICD9 798.0 –ICD10 R95	PM_{10} Annual Mean	Adjusted Odds Ratio AOR=1.12 (1.07-1.17) ↑10µg/m^3	Woodruff et al. 1997
	Cough	PM_{10} Daily Mean	OR=1.041 (1.020-1.062) ↑10µg/m^3	Ward & Ayres 2004
	Lower respiratory symptoms LRS	PM_{10} Daily Mean	OR=1.041 (1.020-1.051) ↑10µg/m^3	Ward & Ayres 2004
CHILDREN – OZONE				
	Emergency room visits for asthma <18 Y ICD9 493, ICD10 J45 J46	Ozone Maximum 1 h	RR=1.0116 (1.0067-1.0165) ↑10µg/m^3	CARB 2004
ADULTS/GENERAL POPULATION				
	Total mortality all causes ICD9 <800 ICD10 A00-R99	Ozone Maximum 8 h Summer	RR= 1.0031 (1.0017-1.0052) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)
	Respiratory mortality ICD9 460-519 ICD10 J00-J99	Ozone Maximum 8 h Summer	RR= 1.0113 (1.0074-1.0151) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)
	Cardiovascular mortality ICD9 390-459 ICD10 I00-I99	Ozone Maximum 8 h Summer	RR= 1.0046 (1.0022-1.0073) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)

To be coherent with mortality findings, it was decided to include RR for hospital admissions in the health impact assessment calculations, even if they were not statistically significant. Furthermore, it was decided that, subject to the publication of new evidence, the RR for respiratory hospital admissions from Anderson's meta-analysis would be used, although they

[1] Cambra K, Alonso E, Cirarda FB, Martínez-Rueda T. Bilbao APHEIS group. Selection of outcomes and exposure response functions for health impact assessment of particles and ozone. Review of the evidence. ENHIS project. WORK PACKAGE 5. Bilbao, February 2005. Http:

[2] Ferran Ballester: Valencian School of Health Studies, Valencia, Spain; Sylvie Cassadou: National Institute of Public Health Surveillance, InVS, Toulouse, France; Fintan Hurley: Institute of Occupational Medicine, Edinburgh, Scotland, UK; Nino Künzli: University of Southern California, Division of Occupational and Environmental Health, Los Angeles, CA, USA; Odile Meckel: Institute of Public Health NRW (LOEGD), Bielfeld, Germany; Hans-Guido Mücke: WHO Collaborating Center (Air)-Federal Environmental Agency, Berlin, Germany; Nikolaos Stilianakis: Institute for Environment and Sustainability, European Commission – JRC, Ispra, Italy.

were not statistically significant (see Table 2). The rationale for that is that if there is sufficient evidence to accept a causal relationship between air pollution and respiratory mortality -both in children-PM and adults-O_3- we should easily accept that there will also be an impact on hospital admissions.

Table 4. Complementary Exposure-response functions (ERF) for health impact assesment on respiratory hospital admissions for children (particles) and adults (ozone)

	OUTCOME	POLLUTANT	RR	SOURCE
CHILDREN - PARTICLES				
	Respiratory hospital admissions 0-14 Y ICD9 460-519 ICD10 J00-J99	*PM_{10}* Daily Mean	*RR= 1.010 (0.998-1.021) ↑10μg/m^3*	*Anderson 2004*
ADULTS/GENERAL POPULATION				
	Hospital respiratory admissions 15-64 Y ICD9 460-519 ICD10 J00-J99	*Ozone Maximum 8 h*	*RR=1.001 (0.991-1.012) ↑10μg/m^3*	*Anderson et al 2004*
	Hospital respiratory admissions >64 Y ICD9 460-519 ICD10 J00-J99	*Ozone Maximum 8 h*	*RR=1.005 (0.998-1.012) ↑10μg/m^3*	*Anderson et al 2004*

Finally, HIA requires the definition of the evaluation scenarios, i.e. the hypothetical scenario with which we want to compare the current air pollution situation. We calculate the impact on health of the (current) air pollution levels in the city that are above the pollution level of the evaluation scenario. In other words, the attributable number of health events (deaths, hospital admissions etc.) calculated for each scenario represents the number of events that would be prevented if, all other things being equal, air pollution levels were reduced to the evaluation scenario level. These evaluation scenarios are based on the objectives and limits established in 1999/30/CE, and 2002/3/CE Directives.

HIA scenarios

1 - HIA scenarios for PM_{10}

1.1.- Scenarios for HIA on **short-term** effects of PM_{10} and **cough, lower respiratory symptoms** in people under 18 year (<18), and **hospital respiratory admissions** in people under 15 year (< 15)

1.1.1 Reduction of PM_{10} levels to a 24-hour value of **50 μg/m^3** in all days exceeding this value (Limit of 1999/30/CE Directive)

1.1.2. Reduction of PM_{10} levels to a 24-hour value of **20 μg/m^3** in all days exceeding this value

1.1.3 Reduction **by 5 μg/m^3** of all the 24-hour values

1.2.- Scenarios for HIA on **long-term** effects of PM_{10} and **postneonatal mortality** (total, respiratory and sudden infant death syndrome-SIDS)

1.2.1 Reduction of the annual mean value of PM_{10} to a level of **40 μg/m^3** (Limit of 1999/30/CE Directive for 2005)

1.2.2 Reduction of the annual mean value of PM_{10} to a level of **20 μg/m^3** (Limit of 1999/30/CE Directive for 2010)

1.2.3 Reduction **by 5 μg/m^3** of the annual mean value of PM_{10}

2.- HIA scenarios on short-term effects of Ozone

1.2.1 Daily maximum 1-hour concentration and **emergency room visits for asthma** in people under 18 year (< 18)

1.2.1.1 Reduction of O_3 daily maximum 1-hour concentrations to a level of **180 µg/m^3** in all days exceeding this value (Information threshold of 2002/3/CE Directive)

1.2.1.2 Reduction **by 10 µg/m^3** of the daily maximum 1-hour concentrations

1.2.2 Daily maximum 8-hour moving average concentration and **mortality** in general population

1.2.2.1 Reduction of O_3 daily maximum 8-hour moving average concentrations to **120 µg/m^3** in all days exceeding this value (Limit for health protection of 2002/3/CE Directive)

1.2.2.2 Reduction **by 10 µg/m^3** in the daily maximum 8-hour moving average concentrations.

Findings

PM_{10}

The annual number of post-neonatal deaths attributable to a reduction of PM_{10} levels by 5 µg/m^3 were estimated to be 4.4 (95%CI: 2.0, 6.8) with smaller number of attributable cases for respiratory and SIDS deaths (Table 5).

Table 5. Potential benefits of reducing PM_{10} levels. Absolute numbers and rates (per 100 000 children) (95% confidence limits) attributable to the health effects of PM_{10}.

	PM10 reduction	**Number of attributable cases per year**
POSTNEONATAL MORTALITY	**Annual mean levels**	
Total	by 5 µg/m^3	4.36 (2.01-6.77)
	to 20 µg/m^3	NA
	to 40 µg/m^3	NA
Respiratory	by 5 µg/m^3	1.35 (0.65-2.08)
	to 20 µg/m^3	NA
	to 40 µg/m^3	NA
SIDS	by 5 µg/m^3	1.60 (0.94, 2.23)
	to 20 µg/m^3	NA
	to 40 µg/m^3	NA
MORBIDITY	**Daily levels**	
Cough <18 y	by 5 µg/m^3	Not Available
	to 20 µg/m^3	NA
	to 50 µg/m^3	NA
LRS <18 y	by 5 µg/m^3	Not Available
	to 20 µg/m^3	NA
	to 50 µg/m^3	NA
Hospital respiratory admissions <15 y	by 5 µg/m^3	82.38 (-16.53, 172.54)
	to 20 µg/m^3	NA
	to 50 µg/m^3	NA

NA: Not applicable if air pollution levels are lower than the scenario level

For O_3, each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations may delay 78 (95%CI: 43.1, 131.7) deaths per year in the study area, 46.7 (95%CI: 22.3, 74.1) from cardiovascular diseases, and 42.4 (95%CI: 27.8, 56.7) from respiratory causes. Results are summarized in Table 6.

Table 6. Potential benefits of reducing ozone daily levels. Absolute numbers and rates (per 100 000 inhabitants) (95% confidence limits) attributable to the health effects of ozone.

	OZONE reduction	**Number of attributable cases per year**
MORTALITY	**Daily 8-h max**	
Total excluding external causes	by 10 µg/m^3	78.54 (43.07, 131.74)
	to 120 µg/m^3	0.25 (0.14, 0.42)
Cardiovascular	by 10 µg/m^3	46.68 (22.32, 74.01)
	to 120 µg/m^3	0.15 (0.07, 0.24)
Respiratory	by 10 µg/m^3	42.42 (27.78, 56.68)
	to 120 µg/m^3	0.15 (0.10, 0.20)
MORBIDITY	**Daily 1-h max**	
Emergency room visits for asthma <18 y	by 10 µg/m^3	Not Available
	to 180 µg/m^3	Not Available
	Daily 8-h max	
Hospital respiratory admissions 15-64 y	by 10 µg/m^3	6.03 (-54.26, 72.35)
	to 120 µg/m^3	0.02 (-0.17, 0.23)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	47.16 (-18.87, 113.20)
	to 120 µg/m^3	0.15 (-0.06, 0.37)

NA: Not applicable if air pollution levels are lower than the scenario level

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