HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Lyon

Summary of main findings for Lyon

In 2001 the PM_{10} annual mean (SD) was 22 (9.7) µg/m^3 (26 (12) µg/m^3 when corrected), above the 1999/30/EC Directive limit value for 2010 (20 µg/m^3), and below that established for 2005 (40 µg/m^3). For the summer period of the same year, the mean (SD), P5 (5th percentile) and P95 of the maximum daily 8-hour moving average concentration of ozone (O_3) were 88 (31), 45 and 142 µg/ m^3, respectively.

Regarding children, infant mortality in Europe is quite low and consequently, the expected attributable number of deaths related to air pollution is also very low. All other things being equal, the reduction of the annual average levels of PM_{10} to 20 µg/m^3 would prevent about 0.4 total post neonatal deaths. Reducing PM_{10} daily mean values to 20 µg/m^3 would prevent about 7 hospital respiratory admissions of children under 15 years old.

As far as short-term effects of O_3 in summer are concerned, all other things being equal, each reduction by 10 µg/m^3 of the daily maximum 8-hour moving average concentrations would avoid about 8 deaths per year in the general study population, 4 from cardiovascular diseases, and 2 from respiratory causes. In terms of hospital admissions, this would represent 1 respiratory admissions in the adult (15-64 years old) population and 5 in the elderly.

Summary of HIA of outdoor air pollution in Lyon 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	62.49	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		25.42	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		13.29	
Total post neonatal mortality	1 month-1 year	Corrected PM_{10}[3]	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		3.48
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.216 (1.102-1.342)			0.65
Postneonatal Sudden Infant Death Syndrom Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		1.65
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		66.96
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)		8.24	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		30.16	

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

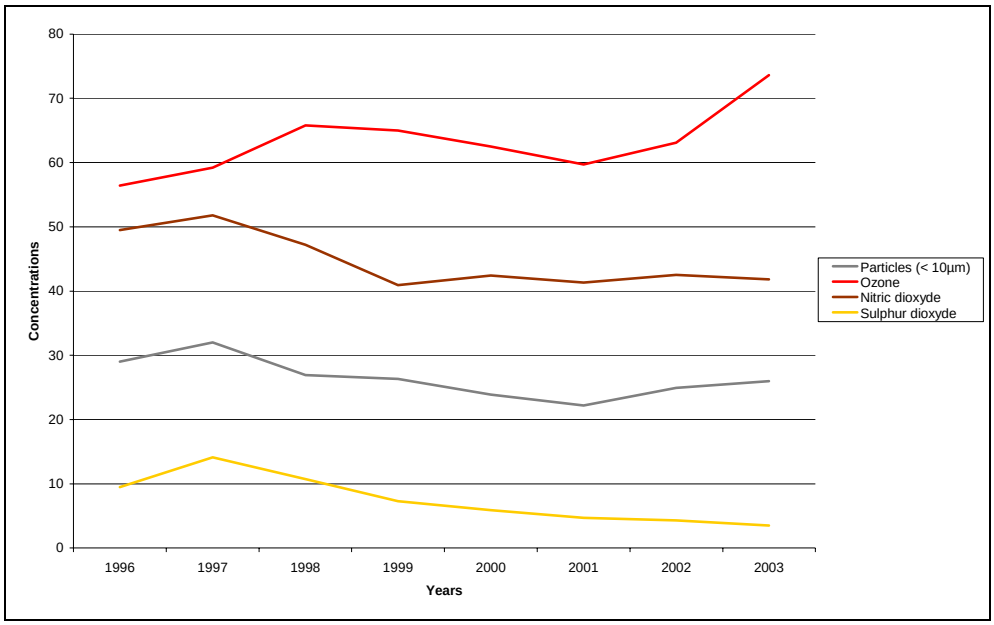
[2] Definition of summer period : 01 April – 30 September

[3] PM_{10} reference papers for HIA on post neonatal 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

- The metropolitan area of Lyon has kept its vocation of river, railway and road crossings, considering its geographical location in the Rhone Valley. A continental climate with anticyclonic conditions of temperature inversion in winter is commonly encountered in the city. Daily mean temperatures range from 8°C in winter to 17°C in summer. The colder months were January, February and March for the year 2002, with respectively 16, 1 and 2 days below 0°C. Conversely, June, July and August were the warmest months with respectively 14, 12 and 15 days above 25°C. The minimum relative humidity is 52%. Rainy months were essentially May, August and November with respectively 13, 13 and 19 days of rainfall above 0.5 mm. Wind speed greater than 3 $m.s^{-1}$ occurred at least 5 days per month in February, March, September, October and December.
- The study area includes 9 municipalities around Lyon with 782 828 inhabitants (15.7% of whom are more than 65 years) spread out on 132 km² of land (density of 5930 inhab./km²). Lyon city counts every day 4,400,000 moves on average which increases by 25% every 10 years. In 1999, an average of 600,000 vehicles penetrated Lyon each day, among them 100,000 and 90,000 cross the Fourvière and Croix-Rousse tunnels, respectively and 200,000 come from both the South and North express roads. Indeed, this influx is explained by the fact that the study area employs about 400,000 people, 60% of whom do not live within it. On the other hand, more than 50% of the 320,000 people live within the study area, but work outside this area.

  Mean annual levels of pollutants from 1996 to 2003 are shown in the following figure.
  PM_{10} mean levels have not significantly changed since 1998. Similarly, levels of NO_2 are constant since 1999. Ozone tends to increase considering the hot summer of 2003. A high mean level of ozone has been observed more in rural areas. Levels of SO_2 show a clear decrease.



- In the Rhone-Alpes region, the life expectancy at birth is higher than the national data (respectively 76.3 years versus 75.4 for men, 83.4 years versus 82.8 for women, in 1999-2001). There are differences among the eight departments of the region (between 75.6 years and 76.7 for men, 82.9 years and 83.8 for women). For

the years 1999-2001, specific annual mortality rate remains less those national for men and women, respectively 12‰ versus 12.6 and 7.1 versus 7.4. Premature mortality among men and women also shows lower values, respectively 2.7 versus 3.1 and 1.1 versus 1.3. Neonatal, post-neonatal and infant mortality is lower than the national one in 1999 (2.6 for 1000 live birth versus 2.9, 1.3 versus 1.6 and 3.9 versus 4.5, respectively). Infant mortality rate has been decreasing constantly since 1982 (8.6 for 1000 live birth). However, since 1996, this decrease is slowing in France, and even more in the Rhone-Alpes region.

Cardiovascular diseases are the main cause of death in the general population of Lyon (31.5% of the whole deaths in 1999). Cardiovascular deaths concern mainly the elderly (90% of the total). Cancers represent the second cause of deaths (29.4% of the whole deaths in 1999), even for the 15-64 years, lung cancer being predominant (183 deaths). The third cause of death concerns respiratory diseases (7.7%).

The main causes of infant mortality in Lyon are mainly congenital abnormalities (5 deaths in 1999), obstetrical traumatism and anoxia (each 3 deaths), and sudden infant death syndrome (1 death) for which the frequency has been decreasing (four time less since 1990 In the Rhone-Alpes region, up to 12 time less in Ain department) since prevention measures have been implemented (adoption of “face upwards” sleeping).

- Air pollution health impact assessment (HIA) has been previously carried out in Lyon and nine communes surrounding (study area), especially during the phases 2 and 3 of Apheis. The most recent analysis (Apheis 3) estimated that reduction of the long-term $PM_{2.5}$ pollution to the levels of 15 µg/m^3 would reduce long-term total mortality in the study area by about 82 deaths in one year, which would save about 34 years of expected life for starting year of simulation. If the daily means of PM_{10} could be kept under 20 µg/m^3, about 19 deaths, and 19 and 35 hospital admissions for cardiovascular and respiratory diseases respectively could have been avoided in the year 2000.
- This report presents the results obtained for the Lyon study area. After a brief description of air pollution sources, exposure and health data, the results of the HIA performed on total and post neonatal mortality, cardiovascular and respiratory mortality, and respiratory hospital admissions in relation with ozone (short-term) and PM_{10} (short- and long-term) are presented.
- 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

According to the CITEPA inventory of emissions for year 2000 for the Rhone Alpes region, together with other mobile sources, road traffic represents 66% of the emissions of nitrogen oxides followed by industrial activities (18%).

Concerning PM_{10}, the repartition of the emissions among sources is more balanced : according to the same inventory, industrial activities represent 36% of the emissions, whereas residential/tertiary activities reach 23% and road traffic and other mobile sources 19%.

Seventy percent of sulphur emissions come from industries (mainly the Feyzin refinery in the Rhone valley) followed by residential/tertiary activites (23%).

Ozone is a secondary air pollutant resulting of complex processes, therefore it is hence not possible to attribute ozone to sources of air pollution.

Exposure data

- Data concerning air pollution levels were obtained from Coparly, the local air pollution monitoring network.
The results of main pollutants concentrations according to the number of measuring stations are recapitulated in the following table in the study area for the year 2002.

Pollutant	Number of stations[1]	Average[2]	Maximum (1 h)[2]	Number of hours in excess[2]
SO_2	17 (7, 6, 4)	2-13	142-436	0-4
NO_2	11 (3, 7, 1)	42-77	141-389	3-41
O_3	4 (3, 1, 0)	25-43	207-246	3-21
PM_{10}	5 (2, 3, 0)	23-32	163-494	61-262
$PM_{2.5}$	1 (0, 1, 0)	32	199	NA
CO	4 (0, 4, 0)	882-1417	4627-11439	0

1: total number of stations
( ): number of stations located in urban, traffic and industrial environment respectively
2: parameters ranges are given when several stations are involved in the measurement of air pollutant

From 1993 to 1999, 4 background monitoring stations (Tapered oscillating microbalance method:TEOM) measured the levels of PM10, and after 1999, 2 stations. Three background monitoring stations measured the levels of ozone.

- In the long term HIA for postneonatal mortality, ENHIS recommended to correct tapered oscillating microbalance method (TEOM) PM10 in order to compensate losses of volatile compounds, because the corresponding RRs were obtained using gravimetric PM10 as a measure of exposure. In Lyon, as part of the French national pilot program for PM surveillance, specific polynomial regression has been used for each city PM10 correction. The coefficients of these regressions were derived from parallel PM10 measurements within each city[1].
- The exposure indicators have been calculated in the following way:
    - For PM10: a daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the stations.
    - For 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 averages 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).
- According to the above definition of exposure indicators, the annual mean level (SD) of TEOM PM10 in Lyon was 22 (9.7) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 10 µg/m^3 and 40 µg/m^3.
The annual mean level (SD) of corrected PM10 in Lyon was 26 (12) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 12 µg/m^3 and 48 µg/m^3. The mean (SD), P5 and P95 of the daily maximum 8-hour moving average concentrations of O_3 (summer) were, respectively, 88 (31), 46 and 142 µg/ m^3, and those of the daily maximum 1-hour concentrations (entire year) 70 (41), 8.4 and 148 µg/m3 (Table 1 and figures 1-3)
- Both TEOM and corrected PM10 levels were lower than the limit value for 2005 (40 µg/m^3). Conversely, there were slightly higher than the limit value for 2010 (20

[1] Jean-Luc HOUDRET, François MATHE. Programme pilote national de surveillance des particules PM_{10} et $PM_{2.5}$. Ecole des mines de Douai, Département Chimie et environnement, Etude n°10. 2003

µg/m^3).
Concerning ozone, the daily maximum 8-hour moving average has been higher than 120 µg/m^3 during 31 days, whereas the target value for 2010 is 120 µg/m^3 not to be exceeded on more than 25 days per calendar year averaged over three years.

- Daily ozone levels (both 1-hour and 8-hour maximum) show a large variability. There are a few days during the summer when ozone levels are very high. Five days correspond to the situation where the information threshold (180 µg/m^3 for 1-hour average) is overshot.
  Daily corrected PM10 levels show a smaller variability. During almost 70% of the days, the daily mean value is between 10 and 30 µg/m^3. During more than 36% of the days, the daily mean value is lower than 20 µg/m^3.

Table 1. Descriptive statistics for ozone and PM10 levels in Lyon study area, 2001

	O3 8h - summer	O3 1h max - year	PM10 - year
Number	183,00	364,00	365,00
Minimum	26,69	0,00	7,77
Percentile 5	44,59	8,38	11,72
Percentile 25	65,11	39,15	16,92
Median	81,97	67,00	23,46
Percentile 75	107,42	93,50	31,49
Percentile 95	141,52	147,80	47,83
Percentile 98	152,16	157,33	60,77
Maximum	194,81	217,00	84,43
Daily mean	87,85	69,53	25,93
standard error	30,59	41,20	12,22
% missing values	0,00%	0,27%	0,00%

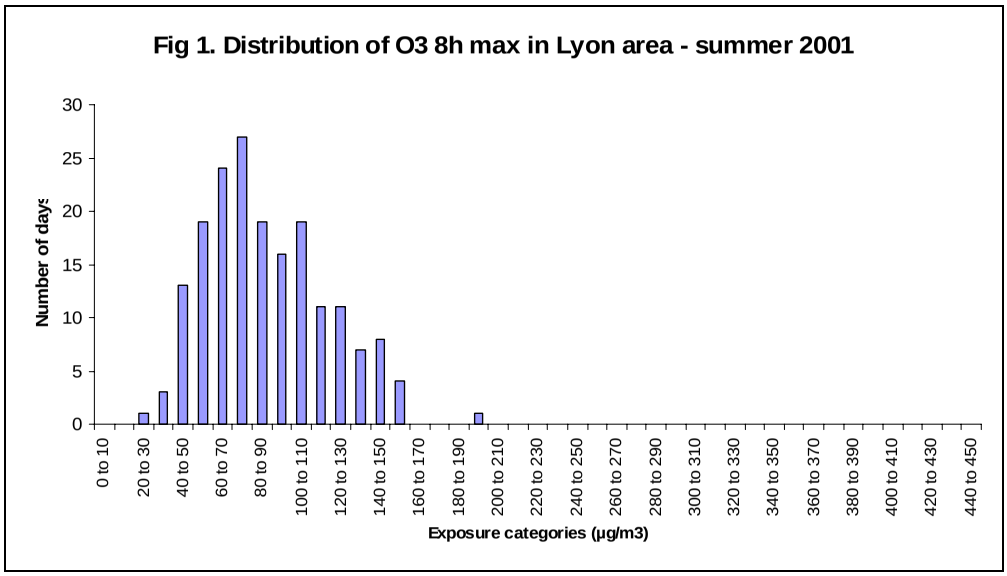


Fig 1. Distribution of O3 8h max in Lyon area - summer 2001
Number of days
0
5
10
15
20
25
30
0 to 10
20 to 30
40 to 50
60 to 70
80 to 90
100 to 110
120 to 130
140 to 150
160 to 170
180 to 190
200 to 210
220 to 230
240 to 250
260 to 270
280 to 290
300 to 310
320 to 330
340 to 350
360 to 370
380 to 390
400 to 410
420 to 430
440 to 450
Exposure categories (µg/m3)

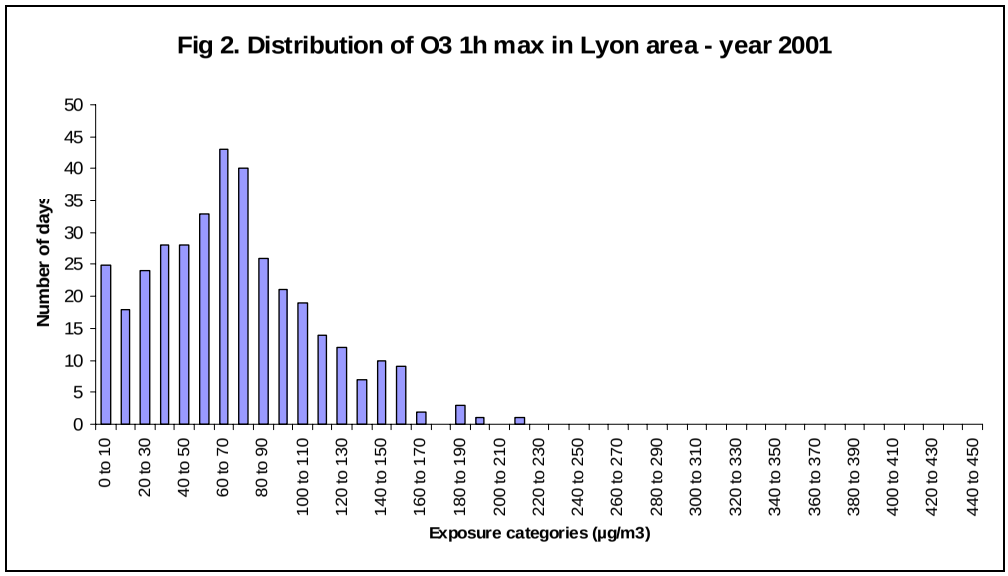


Fig 2. Distribution of O3 1h max in Lyon area - year 2001
Number of days
0
5
10
15
20
25
30
35
40
45
50
0 to 10
20 to 30
40 to 50
60 to 70
80 to 90
100 to 110
120 to 130
140 to 150
160 to 170
180 to 190
200 to 210
220 to 230
240 to 250
260 to 270
280 to 290
300 to 310
320 to 330
340 to 350
360 to 370
380 to 390
400 to 410
420 to 430
440 to 450
Exposure categories (µg/m3)

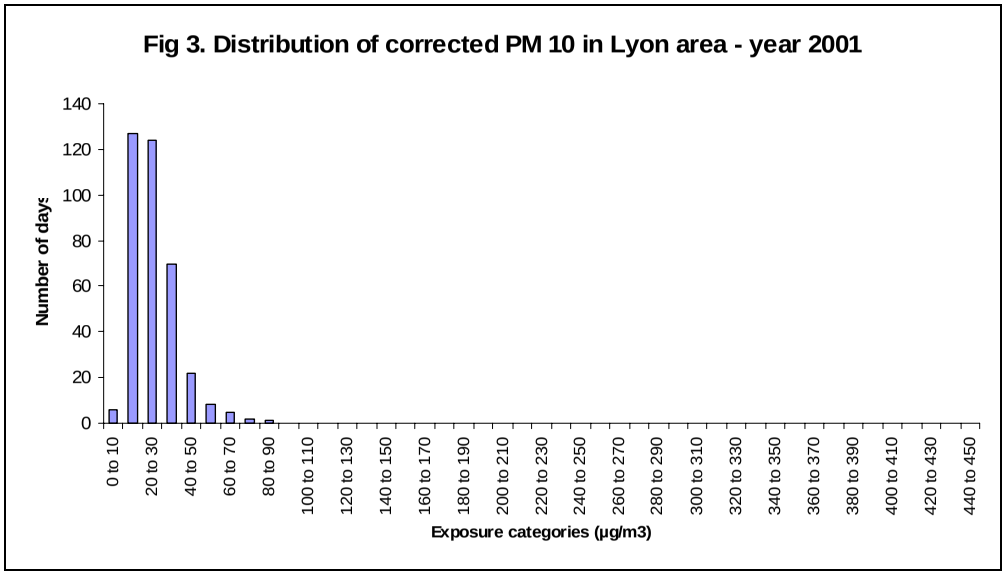


Fig 3. Distribution of corrected PM 10 in Lyon area - year 2001
Number of days
0
20
40
60
80
100
120
140
0 to 10
20 to 30
40 to 50
60 to 70
80 to 90
100 to 110
120 to 130
140 to 150
160 to 170
180 to 190
200 to 210
220 to 230
240 to 250
260 to 270
280 to 290
300 to 310
320 to 330
340 to 350
360 to 370
380 to 390
400 to 410
420 to 430
440 to 450
Exposure categories (µg/m3)

Health data

- Mortality data were obtained from the Institut National de la Santé et de la Recherche Médicale (CepiDC) register. For the year 2001, a quality control program was applied and detected no missing data. Death causes for year 2001 were coded according to the tenth international classification of the diseases (ICD-10). Most of the coding (about 80%) was automated.
- Hospital admissions data concerned public and private hospitals, and were extracted from the Information System Medicalisation Program (PMSI) by the French Institute of Public Health (Invs). These data comprise total hospital admissions data, and hence contain both urgent and non urgent hospital admissions. Hospital admissions causes for year 2001 were coded according to the ICD-10.
- Data concerning specifically emergency hospital admissions, emergency room visit for asthma, cough or lower respiratory syndromes were not available for Lyon study area, and hence no HIA was conduced for these indicators.

The total number of post neonatal deaths in 2001 was 15 (annual rate 160.8 per 100,000), among which 2 were due to sudden infant death syndrome (SIDS) and no to respiratory causes.

The number of deaths in the general population (excluding external causes) was 5513 (annual rate 704.2 per 100,000), among which 1783 (annual rate 227.8 per 100,000) were due to cardiovascular causes, and 317 (annual rate 40.49 per 100,000) were due to respiratory causes.

The annual rate of respiratory admissions was high in both young and elderly people: annual rate for children under 15 was 1056.0 per 100,000 (1364 hospital admissions during 2001), and annual rate among people aged 65 and more was 1556.5 per 100,000 (1913 hospital admissions during 2001). The annual rate for people age between 15 and 64 was really lower : 342.3 per 100,000 (1817 hospital admissions during 2001).

Table 2. Descriptive statistics for health outcomes in Lyon area, 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			15	160.8			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	0	0			
Sudden infant death syndrome *ICD9 798.0 –ICD10 R95*	798.0	R95	2	21.4			
GENERAL POPULATION MORTALITY							
Total mortality, *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			15.1 (4.09)	1.93	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			4.88 (2.23)	0.62	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			0.87 (0.94)	0.11	
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					1056.0
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					342.34
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					1556.5

Health Impact Assessment

Methodology

Health impact assessment of air pollution (AP) involves extrapolation of exposure-health associations measured in epidemiological studies to a target population characterized by a certain observed exposure pattern. Epidemiological studies have provided much of the existing evidence for associations between AP and health effects such mortality and morbidity, supported by the understanding of toxicological and clinical mechanisms. Health outcomes has been calculated as the annual number of health events attributable to AP in the target population. A causal relationship between AP and the effects is assumed, and therefore HIA can only be performed for those outcomes with sufficient evidence of causality. After the choice of health endpoints, the next step is to find the best exposure-response functions (ERFs) for each of them. Table 3 shows the result of a systematic review on these issues carried out by the

Bilbao Apheis team[2] for WP5 of ENHIS-1. This table summarizes the health outcomes and ERFs deemed suitable for HIA according to the criteria established by WP5 with the advice of the air pollution experts of WP5[3].

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

	OUTCOME	POLLUTANT	ERFs	ORIGINAL SOURCE
CHILDREN - PARTICLES				
	Total post neonatal 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, according to the experts' advice, the most recent RRs of hospital admissions in the health impact assessment calculations were chosen, even if they were not statistically significant. The RRs for respiratory hospital admissions from Anderson's meta-analysis could be used (see Table 2). As the rationale for that is supported by a sufficient evidence of a causal relationship between air pollution and respiratory mortality -both in children-PM and adults-O_3-, therefore we should accept that there will also be an impact on hospital admissions.

[2] 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.

[3] 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.

Table 4. Complementary Exposure-response functions (ERFs) 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 needs to define different scenarios to be evaluated. We calculate the impact on health of the (current) air pollution levels in the study area that are above the pollution level of the defined scenario. In other words, the attributable number of health events (deaths, hospital admissions…) calculated for each scenario represents the fewer events that would be prevented if, all other things being equal, air pollution levels were reduced to the considered scenario level according to the objectives and limits based on 1999/30/CE, and 2002/3/CE Directives.

HIA scenarios

1 - HIA scenarios for PM_{10}

1.1.- Results based on scenarios for HIA on **short-term** effects of PM_{10} and **cough, lower respiratory symptoms** in people under 18 year (<18) are not done. Scenarios for HIA on **hospital respiratory admissions** in people under 15 year (< 15) are assessed as follow:

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 **post neonatal 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

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

2.1.1 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)

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

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

Emergency room visits for asthma were not available and results are not done.

Findings

When corrected PM_{10} levels were used as a measure of exposure :

- The annual number of post neonatal deaths attributable to PM_{10} levels higher than 20 $\mu g/m^3$ is 0.15 (95%CI: 0.07 – 0.23), which is equivalent to an annual rate of 1.61 deaths per 100,000 (95%CI: 0.75 – 2.47).

- No number of post neonatal respiratory deaths attributable to PM_{10} levels higher than 20 $\mu g/m^3$ is found.

- The annual number of post neonatal SIDS deaths attributable to PM_{10} levels higher than 20 $\mu g/m^3$ is 0.05 (95%CI: 0.03 – 0.07), which is equivalent to an annual rate of 0.54 deaths per 100,000 (95%CI: 0.32 – 0.75).

Short-term HIA for hospital respiratory admissions were obtained using non corrected PM_{10} values, as the exposure-response function use RRs estimated from epidemiological studies with a measurement of TEOM PM_{10}. The annual number of hospital admissions for respiratory causes of children aged less than 15 attributable to PM_{10} levels higher than 20 $\mu g/m^3$ was 6.50 (95%CI: -1.30 – 13.71), which is equivalent to an annual rate of 5.03 deaths per 100,000 (95%CI: -1.01 – 10.61).

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}.

	PM_{10} reduction	**Number of attributable cases per year**	**Annual rates (per 100.000)**
POSTNEONATAL MORTALITY	**Corrected* annual mean levels**		
Total	by 5 $\mu g/m^3$	0.35 (0.16 – 0.54)	3.75 (1.72 – 5.79)
	to 20 $\mu g/m^3$	0.15 (0.07 – 0.23)	1.61 (0.75 – 2.47)
	to 40 $\mu g/m^3$	NA	NA
Respiratory	by 5 $\mu g/m^3$	0	0
	to 20 $\mu g/m^3$	0	0
	to 40 $\mu g/m^3$	NA	NA
SIDS	by 5 $\mu g/m^3$	0.11 (0.07- 0.15)	1.18 (0.75 – 1.61)
	to 20 $\mu g/m^3$	0.05 (0.03 – 0.07)	0.54 (0.32 – 0.75)
	to 40 $\mu g/m^3$	NA	NA
MORBIDITY	**Measured daily levels**		
Cough <18 y	by 5 $\mu g/m^3$	Not available	
	to 20 $\mu g/m^3$	Not available	
	to 50 $\mu g/m^3$	Not available	
LRS <18 y	by 5 $\mu g/m^3$	Not available	
	to 20 $\mu g/m^3$	Not available	
	to 50 $\mu g/m^3$	Not available	
Hospital respiratory admissions <15 y	by 5 $\mu g/m^3$	6.69 (-1.34 – 14.02)	5.18 (-1.04 – 10.85)
	to 20 $\mu g/m^3$	6.50 (-1.30 – 13.71)	5.03 (-1.01 – 10.61)
	to 50 $\mu g/m^3$	0.18 (-0.04 – 0.38)	0.14 (-0.03 – 0.29)

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

* PM_{10} reference papers for HIA on postneonatal mortality use gravimetric methods to measure PM10. In France, the automatic method (TEOM) is used and required a correction factor to compensate loss of volatile compounds. Therefore, a local polynomial correction factor has been elaborated by the Ecole des Mines (Douai) and used for each French city.

Regarding short-term effects of O_3, each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 8.36 (95%CI: 4.59 – 14.0) deaths per year in the study area, 3.96 (95%CI: 1.90 – 6.29) from cardiovascular diseases, and 1.65 (95%CI: 1.08 – 2.20) from respiratory causes.

Each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 0.90 (95%CI: -8.14 – 19.9) respiratory hospital admissions of people aged between 15 and 64, and 4.61 (95%CI: -1.84 – 11.1) respiratory hospital admissions of people aged 65 and more.

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**	**Annual rates (per 100.000)**
MORTALITY	**Daily 8-h max**		
Total (excluding external causes)	by 10 µg/m^3	8.36 (4.59 – 14.0)	1.07 (0.59 – 1.79)
	to 120 µg/m^3	2.67 (1.46 – 4.48)	0.34 (0.19 – 0.57)
Cardiovascular	by 10 µg/m^3	3.96 (1.90 – 6.29)	0.51 (0.24 – 0.80)
	to 120 µg/m^3	1.29 (0.61 – 2.05)	0.16 (0.08 – 0.26)
Respiratory	by 10 µg/m^3	1.65 (1.08 – 2.20)	0.21 (0.14 – 0.28)
	to 120 µg/m^3	0.58 (0.38 – 0.78)	0.07 (0.05 – 0.10)
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	0.90 (-8.14 - 19.9)	0.17 (-1.53 – 3.74)
	to 120 µg/m^3	0.28 (-2.51 – 3.41)	0.05 (-0.47 – 0.64)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	4.61 (-1.84 – 11.1)	3.75 (-1.50 – 9.01)
	to 120 µg/m^3	1.50 (-0.60 – 3.64).	1.22 (-0.49 – 2.96)

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

Discussion

HIA needs to include health endpoints based on concentration-response coefficients and for which reliable evidence has been obtained from epidemiological studies.

Mortality data are highly reliable, and hence do not represent a major source of uncertainty for the results of the present HIA. Conversely, hospital admissions data present a greater source of uncertainty because they include both urgent and non urgent hospital admissions, the last being not temporally linked with the levels of air pollution. Other factors are represented by delays in hospital admission from emergency rooms, differences in levels of diagnostic agreement between hospitals, age groups, and outcome groups. Nevertheless, risk estimates used for the HIA are those of epidemiological studies using similar framework of databases for hospital admissions.

The key uncertainty is how well the daily variations in the particle concentration measured at a central site correlate with the variations in average personal exposure. However, the concentration-response coefficients are estimated in epidemiological studies using average measures of concentrations which are also used for the HIA.

In Lyon study area, ozone levels in 2001 are not compliant with target value for 2010 (120 µg/m^3 not to be exceeded on more than 25 days per calendar year averaged over three years) and, therefore some deaths (total, cardiovascular and respiratory) are attributable to daily ozone 8-h max levels above 120µg/m^3 (respectively about 2.67, 1.29 and 0.58, see table 6). Hence, compliance with long term objectives for ozone (maximum daily 8-hour mean within a calendar year lower than 120µg/m^3) would induce health benefits for the population in terms of deaths,

and probably of hospital admissions. Reduction of daily 8-h max levels of ozone by 10µg/m^3 would induce even larger health benefits in terms of mortality (respectively 8.36, 3.96 and 1.65 for total, cardiovascular and respiratory mortality, respectively).

PM_{10} levels are compliant with 2005 limit values (40µg/m^3) and hence no cases are attributable for the scenario corresponding to a reduction of the annual mean to 40µg/m^3. Conversely, a significant number of attributable post neonatal deaths for a reduction of the annual mean by 5 µg/m^3 to 20 µg/m^3 (2010 limit value) is shown. The number of post neonatal deaths attributable to PM_{10} levels higher than 20 µg/m^3 has proven to be highly sensitive to the values used to assess the exposure to PM_{10}.

The need for a better assessment of PM_{10} exposure for long-term HIA is needed. The use of correction factors does not seem appropriate, as the proportion of volatile matter within the particles varies according to multiple factors (meteorological conditions, chemical composition of particles…). New methods of measurement (Sampler equilibration system, for example) avoiding loss of volatile matter might be a better way of assessing PM_{10} exposure for the purpose of long-term HIA.

The numbers of attributable cases may seem small, especially when compared with the number of deaths attributable to other risk factors, especially tobacco smoking. However, control strategies to improve quality of air would have a large impact as they concern the whole population, whereas exposure to other risk factors are addressed at the individual level, and therefore not so easy to implement or do not necessary lead to success.

Conclusion

The results from the present HIA may help promoting measures aiming at reducing air pollutant emissions, especially traffic linked emissions, as health benefits are a powerful way of motivating changes in individuals comportments. So it represents a necessary tool in the decision making process in order to limit health impact of air pollution.

References

ANDERSON R, ATKINSON R, PEACOCK JL, MARSTON L AND KONSTANTINOU K Metaanalysis of time-series and panel studies on Particulate Matter and Ozone (O3). WHO Task Group. WHO Regional Office for Europe, Copenhagen 2004 (EUR/04/5042688).

APHEIS 3. Health Impact Assessment of Air Pollution and Comunication Strategy. Third Year Report 2002-2003. July 2004. available in: http://europa.eu.int/comm/health/ph_projects/2001/pollution/fp_env_2001_frep_en.pdf

CARB 2004. California Air Resources Board. Quantifying the health benefits of reducing ozone exposure. Available in http://www.arb.ca.gov/research/aaqs/ozone-rs/ch10.pdf

GRYPARIS A, ET AL. Acute effects of ozone on mortality from the "Air Pollution and health: A European Approach" Project. *Am J Respir Crit Care Med*. Vol 170: 1080-1087. (2004)

LACASAÑA M, Esplugues A and Ballester F. Exposure to ambient air pollution and prenatal and early childhood health effects. *European Journal of Epidemiology* 20: 183-189. (2005).

OFFICIAL JOURNAL OF THE EUROPEAN COMMUNITIES. Directive 1999/30/CE of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. DOCE L163, 29/6/1999.

OFFICIAL JOURNAL OF THE EUROPEAN COMMUNITIES. Directive 2002/3/EC of 12 February 2002 relating to ozone in ambient air. DOCE L67/14, 9/03/2002.

WARD DJ, AND AYRES J G. Particulate air pollution and panel studies in children: a systematic review. Occup Environ Med. 61(4): e13. Review. (2004).

WHO The effects of air pollution on children's health and development: a review of the evidence. Executive Summary. Available in: http://www.euro.who.int/document/EEHC/execsum.pdf

WOODRUFF TJ ET AL : The relationship between selected causes of post neonatal infant mortality and particulate air pollution in the United States. Environ Health Perspect 1997, 105: 608-612. http://ehp.niehs.nih.gov/members/1997/105-6/woodruff.html