HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Paris

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Summary of main findings for Paris

In 2001 the PM_{10} annual mean (SD) was 22 (9) µg/m^3 (27 (13) µg/m^3 when a correction is applied in order to compensate losses of volatile compounds due to the TEOM measurement method), 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 78 (31), 35 and 142 µg/ m^3.

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 5 total postneonatal deaths. Reducing PM_{10} daily mean values to 20 µg/m^3 would prevent about 63 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 delay about 62 deaths per year in the general population in the study area, 25 from cardiovascular diseases, and 13 from respiratory causes. In terms of hospital admissions, this would represent 8.24 respiratory admissions in the adult (15-64 years old) population and 30.16 in the population over 64 years.

Summary of HIA of outdoor air pollution in Paris 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 postneonatal 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 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 *(please describe the following issues)*

- The study area includes Paris and the three surrounding departments (Hauts-de-Seine, Seine-Saint-Denis and Val-de-Marne), representing a total area of 762.24 km². The population living in this area in 1999 is estimated to 6,174,000 inhabitants. It is a densely populated urban area, concentrating a lot of transportation infrastructures: highways, roads, railway, and two international airports located at the outskirts of this area.
  In this area, linked to the closure of some industrial plants, and to increased regulations on the remaining ones, sulfur dioxide air pollution has been decreasing for 30 years now, and the levels are now around 10µg/m^3 (annual mean, background levels).
  A decrease has also been observed for carbon monoxide and benzene. These decreases are mainly attributable to technical improvement of vehicles.
  Particular air pollution levels keep steady for about 5 years.
  Nitrogen dioxide air pollution has been showing a slight decreasing trend since the middle of the 90's. However, there seems to be a stabilization of the levels during the recent years. In Paris metropolitan area, NO_x emissions are mainly due to road traffic, and in most of the study area, where traffic density is high, background mean annual levels are higher than the national air quality guideline (40µg/m^3).
  Ozone levels show an increasing trend since the beginning of the 90's. This trend may correspond to an increase of background levels, and an increase of both intensity and frequency of summer peaks.

- In this study area, the life expectancy is higher than the French one. However, there are differences among the four departments composing the study area, and mortality of children aged less than one year is higher in this area than the national one. Infant mortality rate has been decreasing constantly. However, since the beginning of the 90's, this decrease slows in France, and even more in the study area.
  The main causes of infant mortality in the study area are conditions arising during the perinatal period and congenital anomalies. Sudden infant death syndrome frequency has been decreasing since prevention measures have been implemented (recommendations on sleeping position of babies).
  Cancer is the main cause of deaths in the general population of the study area: cancers represent an important cause of death even in the youngest part of the population, and they are the most important cause of deaths in people aged 40 and more. Cardiovascular diseases are the second most important cause of death in the study area, even if cardiovascular death rate is lower in the study area than the national French one. Cardiovascular deaths are concentrated in the oldest part of the population.

- Air pollution Health impact assessment (HIA) have been previously carried out in the study area, especially during the phases 2 and 3 of Apheis. The most recent analysis (Apheis 3) estimated that reduction of the long-term PM2.5 pollution to the levels of 15 ug/m3 would reduce mortality in the study area by about 850 deaths in one year, which would save about 410 years of expected life for starting year of simulation. If the daily means of PM10 would be kept under 20 ug/m3, about 100 deaths and 140 hospital admissions for cardiovascular causes could have been avoided in the year 2000.

- This report presents the results obtained for the Paris study area. After a brief description of air pollution sources, exposure and health data, the results of the HIAs conduced on postneonatal mortality, cardiovascular and respiratory mortality, and respiratory hospital admissions in relation with ozone (short-term) and PM10 (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

The main source of nitrogen oxides within the study area is road traffic: according to the Airparif/Drire inventory of emissions for year 2000, together with other mobile sources, road traffic represents 62% of the emissions.

Concerning PM10, the repartition of the emissions among sources is more balanced : according to the same inventory, road traffic and other mobile sources represent about 40% of the emissions, whereas production processes represent about 31%, and combustions (energy production and transformation, garbage incineration, etc.) 29%.

Ozone is a secondary air pollutant. Its formation is the result of complex processes. It is hence not possible to attribute ozone to sources of air pollution.

Exposure data

- Data concerning air pollution levels were obtained from Airparif, the local air pollution monitoring network. Within the study area in 2001, 8 background monitoring stations (TEOM) measured the levels of PM10, and 10 background monitoring stations measured the levels of ozone.
  For HIA purpose for chronic exposure, ENHIS recommended to correct 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 Paris, 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].
- How indicators have been calculated:
  - 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 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).
- AP data description:
  The annual mean level (SD) of TEOM PM10 in Paris was 22 (9) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 11 µg/m^3 and 42 µg/m^3.
  The annual mean level (SD) of corrected PM10 in Paris was 27 (13) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 13 µg/m^3 and 55 µg/m^3. The mean (SD) , P5 and P95 of the daily maximum 8-hour moving average concentrations of O_3 (summer) were, respectively, 78 (31), 35 and 142 µg/ m^3, and those of the daily maximum 1-hour concentrations (entire year) 66 (37), 14 and 140 µg/m3 (Table 1 and figures 1-3)
- Both TEOM and corrected PM10 annual mean levels were lower than the limit value for 2005 (40µg/m^3). However, both TEOM and corrected PM10 annual mean levels were slightly higher than the limit value for 2010 (20µg/m^3).
  Concerning ozone, the daily maximum 8-hour moving average has been higher than 120µg/m^3 during 22 days, whereas the target value for 2010 is 120 µg/m3 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. Among these days, some correspond to situation where the information threshold (180

[1] Jean-Luc HOUDRET, François MATHE. Programme pilote national de surveillance des particules PM10 et PM2.5. Ecole des mines de Douai, Département Chimie et environnement, Etude n°10. 2003

µg/m^3 for 1-hour average) was overshot.
Daily corrected PM10 levels show a smaller variability. During more than 65% of the days, the daily mean value is between 10 and 30 µg/m^3. During slightly less than 30% of the days, the daily mean value is lower than 20µg/m^3.

Table 1. Descriptive statistics for ozone and PM_{10} levels in Paris area, 2001

	O3 8h - summer	O3 1h max - year	Corrected PM10 - year
Number	183	365	365
Minimum	17	2	8
Percentile 5	35	14	13
Percentile 25	57	42	18
Median	72	60	24
Percentile 75	91	83	33
Percentile 95	142	140	55
Percentile 98	155	166	60
Maximum	160	202	95
Daily mean	78	66	27
standard error	31	37	13
% missing values	0.00%	0.00%	0.00%

Fig 1. Distribution of O3 8h max in Paris area - summer 2001

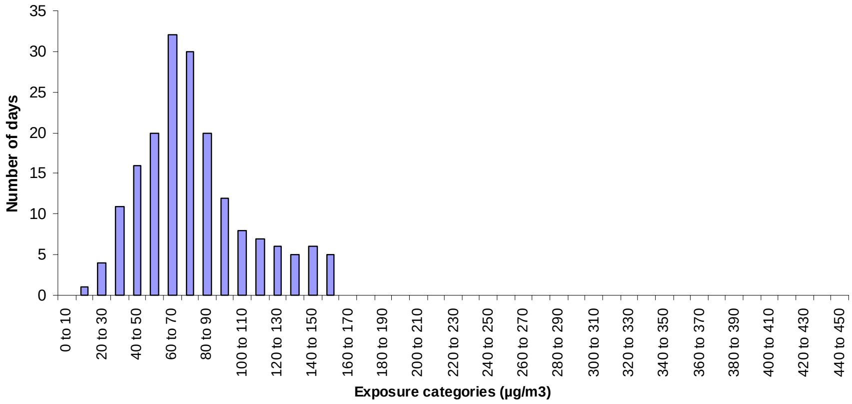


Fig 2. Distribution of O3 1h max in Paris area - year 2001

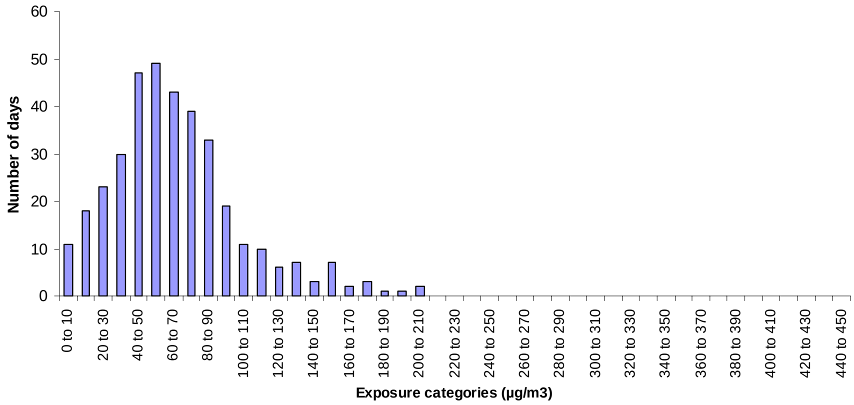
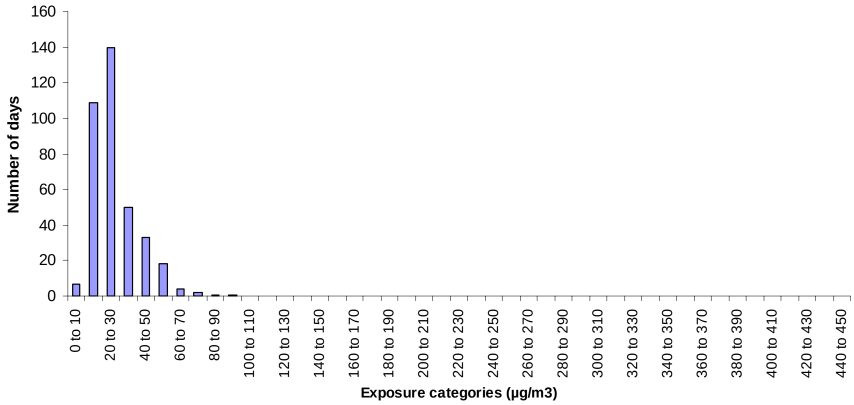


Fig 3. Distribution of corrected PM 10 in Paris area - year 2001



Health data

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

The total number of postneonatal deaths in 2001 was 150 (annual rate 183.87 per 100,000) , among which 7 were due to respiratory causes and 30 to sudden infant death syndrome.

The number of deaths in the general population (excluding external causes) was 41,056 (annual rate 664.89 per 100,000), among which 11,370 (annual rate 184.16 per 100,000) were due to cardiovascular causes, and 2530 (annual rate 40.98 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 1218.59 per 100,000 (13,659 hospital admissions during 2001) , and annual rate among people aged 65 and more was 1530.08 per 100,000 (12,445 hospital admissions during 2001). The annual rate for people age between 15 and 64 was really lower : 390,14 per 100,000 (16,541 hospital admissions during 2001).

Table 2. Descriptive statistics for health outcomes in Paris 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			150	183.87			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	7	8.58			
Sudden infant death syndrome *ICD9 798.0 –ICD10 R95*	798.0	R95	30	36.77			
GENERAL POPULATION MORTALITY							
Total mortality, *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			112.48 (14.11)	1.82	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			31.15 (6.41)	0.50	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			6.93 (3.05)	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					1218.59
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					390.14
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					1530.08

Health Impact Assessment

Methodology

Health impact of air pollution (AP) 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. Once the effects with sufficient evidence of causal relationship with AP have been determined, the next step is to find the best exposure-response functions (ERFs) for each of the selected outcomes. 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].

[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. Http:

[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 3. Health outcomes and Exposure-response functions (ERFs) 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, with the experts' advice, to include RRs of hospital admissions in the health impact assessment calculations, even if they were not statistically significant. More concretely, it was decided that if there was not any new RR published by the time of making the calculations, the RRs for respiratory hospital admissions from Anderson's meta-analysis could be used, although they 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 (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 defining 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…) 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

For long-term HIA, corrected PM10 levels were used as a measure of exposure. The following results were found:

- The annual number of postneonatal deaths attributable to PM_{10} levels higher than 20 µg/m^3 was 5.16 (95%CI: 2.37 – 8.03), which is equivalent to an annual rate of 6.32 deaths per 100,000 (95%CI: 2.90 – 9.84).

- The annual number of postneonatal respiratory deaths attributable to PM_{10} levels higher than 20 µg/m^3 was 0.95 (95%CI: 0.45 – 1.48), which is equivalent to an annual rate of 1.16 deaths per 100,000 (95%CI: 0.55 – 1.81).

- The annual number of postneonatal SIDS deaths attributable to PM_{10} levels higher than 20 µg/m^3 was 2.43 (95%CI: 1.43 – 3.43), which is equivalent to an annual rate of 2.98 deaths per 100,000 (95%CI: 1.75 – 4.20).

Short-term HIA of PM10 on hospital respiratory admissions were calculated using TEOM PM10, as the corresponding RRs were obtained using TEOM measured values as an assessment of PM10 exposure. The annual number of hospital admissions for respiratory causes of children aged less than 15 attributable to PM_{10} levels higher than 20 µg/m^3 was 63.52 (95%CI: -12.66 – 133.85), which is equivalent to an annual rate of 5.67 deaths per 100,000 (95%CI: -1.13 – 11.94).

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**	**Annual rates (per 100.000)**
POSTNEONATAL MORTALITY	**Corrected* annual mean levels**		
Total	by 5 µg/m^3	3.48 (1.60 - 5.40)	4.26 (1.96 – 6.16)
	to 20 µg/m^3	5.16 (2.37 - 8.03)	6.32 (2.90 – 9.84)
	to 40 µg/m^3	NA	NA
Respiratory	by 5 µg/m^3	0.65 (0.32 - 1.01)	0.79 (0.39 – 1.24)
	to 20 µg/m^3	0.95 (0.45 - 1.48)	1.16 (0.55 – 1.81)
	to 40 µg/m^3	NA	NA
SIDS	by 5 µg/m^3	1.65 (0.98 - 2.31)	2.02 (1.20 – 2.83)
	to 20 µg/m^3	2.43 (1.43 - 3.43)	2.98 (1.75 – 4.20)
	to 40 µg/m^3	NA	NA
MORBIDITY	**Measured daily levels**		
Cough <18 y	by 5 µg/m^3	Not available	Not available
	to 20 µg/m^3	Not available	Not available
	to 50 µg/m^3	Not available	Not available
LRS <18 y	by 5 µg/m^3	Not available	Not available
	to 20 µg/m^3	Not available	Not available
	to 50 µg/m^3	Not available	Not available
Hospital respiratory admissions <15 y	by 5 µg/m^3	66.96 (-13.43 – 140.23)	66.96 (-13.43 – 140.23)
	to 20 µg/m^3	63.52 (-12.66 – 133.85)	63.52 (-12.66 – 133.85)
	to 50 µg/m^3	1 (-0.20 – 2.10)	1 (-0.20 – 2.10)

NA: Not applicable <u>if air pollution levels are lower than the scenario level</u>

* PM_{10} reference papers for HIA on postneonatal mortality use gravimetric methods to measure PM_{10}. In France, the automatic methods (TEOM) was used, and a correction factor is required to compensate for loss of volatile compounds: a local polynomial correction factor elaborated by the Ecole des Mines de Douai was used for each French city, see p. 5.

Regarding short-term effects of O_3, each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 62.46 (95%CI: 34.27 – 104.82) deaths per year in the study area, 25.42 (95%CI: 12.16 – 40.34) from cardiovascular diseases, and 13.29 (95%CI: 8.70 – 17.75) from respiratory causes.

Each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 8.24 (95%CI: -74.14 – 98.87) respiratory hospital admissions of people aged between 15 and 64, and 30.16 (95%CI: -12.07 – 72.39) 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	62.46 (34.27 - 104.82)	1.01 (0.55 – 1.70)
	to 120 µg/m^3	15.41 (8.44 - 25.90)	0.25 (0.14 – 0.42)
Cardiovascular	by 10 µg/m^3	25.42 (12.16 - 40.34)	0.41 (0.20 – 0.65)
	to 120 µg/m^3	6.38 (3.05 - 10.15)	0.10 (0.05 – 0.16)
Respiratory	by 10 µg/m^3	13.29 (8.70 - 17.75)	0.21 (0.14 – 0.29)
	to 120 µg/m^3	3.61 (2.36 - 4.84)	0.06 (0.04 – 0.08)
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	8.24 (-74.14 - 98.85)	0.19 (-1.75 – 2.33)
	to 120 µg/m^3	1.98 (-17.67 - 24.02)	0.05 (-0.42 – 0.57)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	30.16 (-12.07 - 72.39)	3.71 (-1.48 – 8.90)
	to 120 µg/m^3	7.61 (-3.02 – 18.38).	0.94 (-0.37 – 2.26)

Discussion

Mortality data are highly reliable, and hence do not represent a major source of uncertainty for the results of the present HIAs. On the contrary, hospital admission data present a major source of uncertainty because they include both emergency hospital admissions and scheduled hospital admissions, that are certainly not temporally linked with the levels of air pollution. Hence, the numbers of attributable hospital admissions are certainly over-estimated.

In Paris study area, ozone levels in 2001 are compliant with target value for 2010 (120 µg/m3 not to be exceeded on more than 25 days per calendar year averaged over three years). However, there is a significant number of deaths (total, cardiovascular and respiratory) attributable to daily ozone 8-h max levels above 120µg/m^3 (respectively about 15.41, 6.38 and 3.61, 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 62.46, 25.42 and 13.28 for total, cardiovascular and respiratory mortality).

PM10 levels are compliant with 2005 limit values (40µg/m^3). Hence, there are no attributable cases for the scenario corresponding to a reduction of the annual mean to 40µg/m^3. However, there is a significant number of attributable postneonatal deaths for both a reduction of the annual mean by 5µg/m^3 and a reduction of the annual mean to 20µg/m^3 (2010 limit value). Hence, compliance with 2010 limit value for PM10 would certainly induce health benefits in the study area, especially in terms of postneonatal mortality.

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, air pollution exposure concerns everyone, whereas exposure to other risk factors may be more easy to control at the individual level.

Conclusion

The results from the present HIAs 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 behaviours.

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