HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Bordeaux

Summary of main findings for Bordeaux

In 2001 the PM_{10} annual mean (SD) was 21 (10) µg/m^3 (25 (14) µg/m^3 when a correction was applied 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 84 (24), 50 and 130 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 0.24 total postneonatal deaths and 4.68 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 7.05 deaths per year in the general population in the study area, 3.53 from cardiovascular diseases, and 1.40 from respiratory causes. In terms of hospital admissions, this would represent 0.90 respiratory admissions in the adult population (15-64 years old) and 3.23 in the population over 64 years.

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

Health outcome	Population	Pollutant	Period	Mean type	RR (for 10 µg.m^3 increase)	*References*	Number of attributable cases by scenario*	
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	7.05 (3.86 – 11.82)	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		3.53 (1.69 – 5.60)	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		1.40 (0.92 – 1.87)	
Total postneonatal mortality	1 month- 1 year	Corrected PM_{10}†	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		0.23 (0.11 – 0.36)
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.216 (1.102-1.342)			0.00 (–) ‡
Postneonatal Sudden Infant Death Syndrom Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		0.06 (0.03 – 0.08)
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		5.64 (-1.13 – 11.81)
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)		0.90 (-8.11 – 10.81)	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		3.23 (-1.29 – 7.74)	

* f<u>or ozone</u>: absolute reduction by 10 µg/m^3; f<u>or PM_{10}</u>: absolute reduction by 5 µg/m^3

** Definition of summer period : 01 April – 30 September

† PM_{10} reference papers for HIA on postneonatal mortality use gravimetric methods to measure PM_{10}. Since the local air quality network uses automatic methods (TEOM), a local correction factor was used to compensate for loss of volatile compounds

‡ in Bordeaux area, there was no case of postneonatal respiratory mortality in 2001

Introduction

- The study area includes Bordeaux and 21 other surrounding municipalities, representing a densely populated area of 334 km². The population living in this area was estimated to 604 238 inhabitants in the last census of population in 1999 (i.e. a population density of 1717.5 inhabitants per km²).
- Bordeaux is situated in the south-west of France, near the Atlantic ocean; it is therefore influenced by the oceanic climate. 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 and the levels are now around 5 µg/m^3 (annual mean, background levels). Concerning ozone levels, an increasing trend has been observed for a decade with an increase of both background levels and frequency of summer peaks.
- In the study area of Bordeaux, global mortality rate if significantly lower than the French one and is mainly caused by diseases of the circulatory system, trauma and tumours. Infant mortality rate is similar to the French one, and postneonatal deaths are mainly caused by conditions arising during the perinatal period and congenital anomalies. However, the mortality rate attributable to these pathologies - as to the others - has constantly been decreasing for the past decades.
- Previous air pollution Health Impact Assessments (HIA) were already carried out in this study area. Recently, Apheis 3 estimated that a reduction of the long term $PM_{2.5}$ pollution of 15 µg/m^3 would reduce mortality by 24 deaths in one year, which would save 7 years of expected life for starting year of simulation. If the daily mean of PM_{10} would be kept under 20µg/m^3, 11 deaths and 26 hospital admissions could have been avoided in the year 2000.
- In this report are presented the results for air pollution HIA in the city of Bordeaux concerning postneonatal mortality, cardiovascular and respiratory mortality, and respiratory hospital admissions in relation with ozone (short-term) and PM_{10} (short- and long-term).
- 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

Data concerning sources of pollution are only available for the Aquitaine region, and not for Bordeaux especially (source: Citepa given of 2000).

- Road traffic constitutes the main source of nitrogen oxides since it represents 58% of the emissions
- Concerning PM_{10}, the repartition is more balanced and the three main sources are agriculture (27%), industry and waste management (24%), and residential (24%); whereas road traffic only represents 13% of the emissions. However, we can suppose that in Bordeaux pollution due to industry and road traffic is more important since there is no much agriculture in our study area.
- Since ozone is a secondary air pollutant resulting from complex processes, it is not possible to know it main sources.

Exposure data

- Air pollutants were measured by AIRAQ, the local air pollution monitoring network. Within the study area, 4 monitoring background stations were used to measure particles and ozone. PM_{10} were measured by the TEOM method (Tapered Element Oscilling Micro-balance).
- In order to compensate losses of volatile compounds, it was recommended to correct TEOM PM_{10} because the corresponding RRs were obtained using gravimetric PM_{10} as a measure of exposure. Therefore specific polynomial regressions have been used for PM_{10} correction. The coefficients of these regressions were derived from parallel PM_{10} measurements within each Enhis French city [1].

- Exposure has been estimated as follows:
  - PM_{10}: daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the four background stations.
  - O_3: daily maximum 8-hour moving averages have been calculated as the arithmetic mean of the maximum 8-hour moving averages of the four stations for the summer period (1st April to 30th September). A daily maximum 1-hour indicator has also been calculated as the arithmetic mean of the 1-hour maximum of the four stations.

- AP data description for year 2001:

  A description of O_3 and PM_{10} mean levels are given in Table 1.

Table 1. Descriptive statistics for O_3 and PM_{10} levels in Bordeaux (2001)

	O_3 8h - summer	O_3 1h max - year	TEOM PM_{10} - year	Corrected PM_{10} - year
Number	183	365	365	365
Minimum	40	9	5	5
Percentile 5	50	25	10	11
Percentile 25	67	51	15	16
Median	80	66	19	21
Percentile 75	99	89	24	29
Percentile 95	130	131	38	49
Percentile 98	138	144	46	62
Maximum	146	185	83	130
Daily mean	84	71	21	25
standard error	24	31	10	14
% missing values	0,00%	0,00%	0,00%	0,00%

The mean (SD) of the daily maximum 8-hour moving average concentrations of O_3 during summer 2001 was 84 (24) µg/ m^3; P5 and P95 were respectively 50 and 130 µg/m^3. Concerning the daily maximum 1-hour concentrations, the mean (SD) was 71 (31); P5 and P95 were respectively 25 and 131 µg/m^3.

[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

The annual mean level (SD) of TEOM PM_{10} in Bordeaux area was 21 (10) µg/m^3; P5 and P95 of the daily mean values were respectively, 10 and 38 µg/m^3. When the local correction factor was applied, the annual mean level (SD) of corrected PM_{10} was 25 (14) µg/m^3; P5 and P95 of the daily mean values were respectively 11 and 49 µg/m^3.

Both TEOM and corrected PM_{10} mean levels were much lower than the limit value for 2005 (40µg/m^3), but were slightly higher than the limit value for 2010 (20µg/m^3).

Figure 1 and 2 represent the distribution of daily O_3 (8- and 1-hour maximum respectively) and show a large variability of these indicators. The information threshold of 180 µg/m^3 was overshot just one day, for the 1-hour average only. The daily maximum 8-hour moving average of O_3 has been higher than 120µg/m^3 on 18 days in 2001, 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.

Fig 1. Distribution of daily O3 8h max in Bordeaux area. Summer 2001

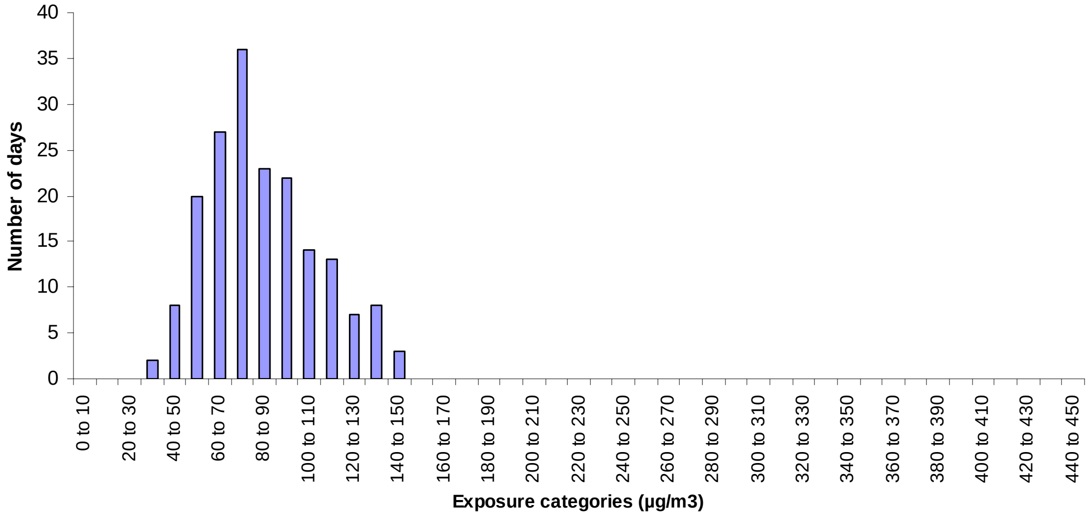
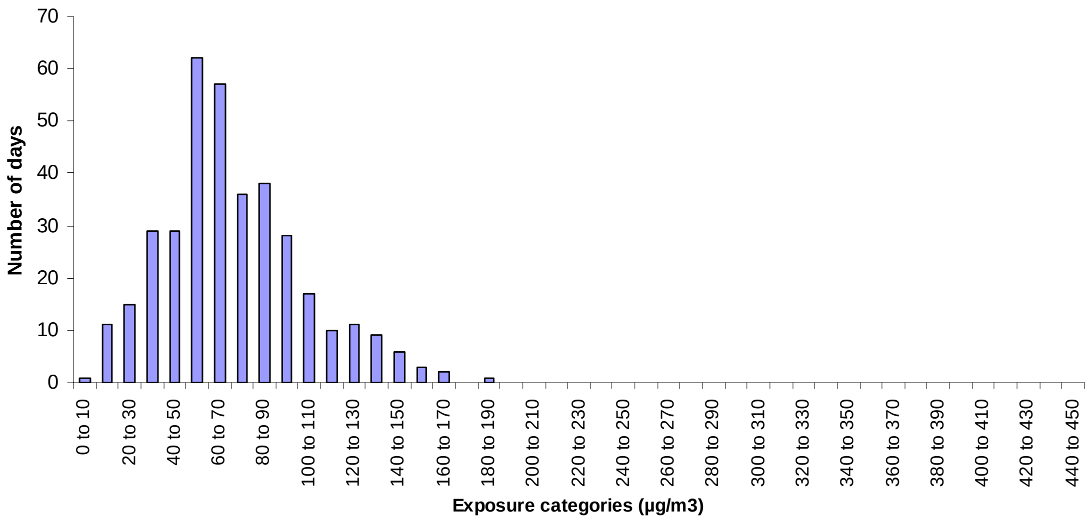
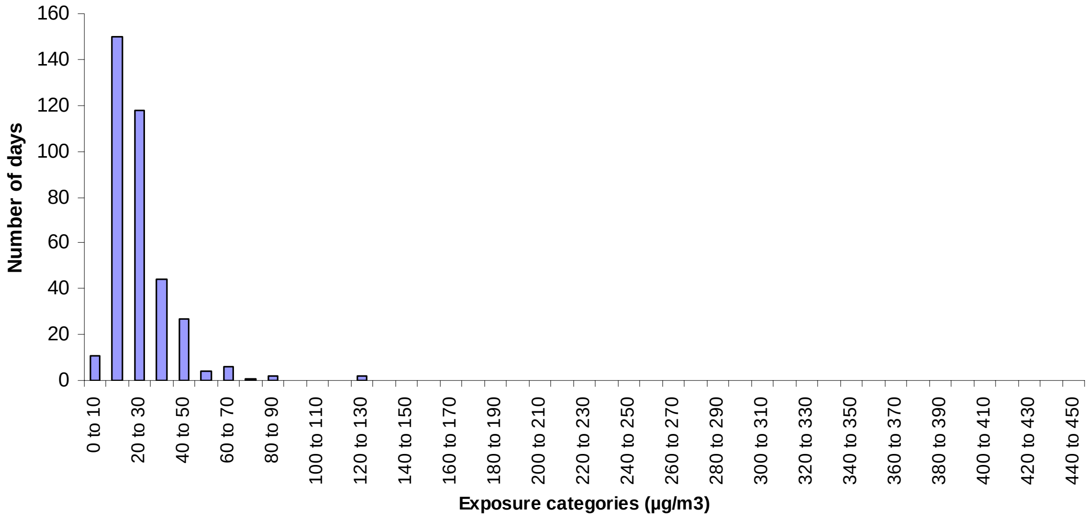


Fig 2. Distribution of daily O3 1h max in Bordeaux area. Year 2001



As shows Figure 3, corrected PM_{10} mean levels are mostly between 10 and 30 µg/m^3 (during 73% of the period). The limit value for 2010 (20µg/m^3) is respected during nearly half of the year (44%).

Fig 3. Distribution of daily corrected PM10 in Bordeaux area. Year 2001



Health data

- Mortality data were provided by the information department specialised in mortality data (CepiDC) of the National Health and Medical Research Institute (Inserm). The most recent available data were for year 2001. Causes of deaths were coded according to the international classification of diseases (ICD-10), and most of the coding (about 80%) was automated. There is no missing data, and a quality control program is applied.
- Data on hospital admissions were collected from the Information Systems Medicalisation Program (PMSI) for year 2001 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 were also coded according to ICD-10.
- Data concerning specifically emergency hospital admissions, emergency room visit for asthma and cough or lower respiratory syndromes were not available in Bordeaux, and health impact has not been assessed for these indicators.

Health outcomes that occurred in Bordeaux area in 2001 are described in Table 2.

The total number of postneonatal deaths was 10 (annual rate 154 per 100,000), among which 1 was due to sudden infant death syndrome; none of these deaths was related to respiratory causes.

The daily mean of deaths in the general population (excluding external causes) was 12.7 (annual rate 2.1 per 100,000), among which 4.3 were due to cardiovascular causes and 0.7 to respiratory causes.

The annual rate of respiratory admissions was at least three times higher in children under 15 (1226 per 100,000) and elderly people (1412 per 100,000) than among adults between 15 and 64 (436 per 100,000).

Table 2. Descriptive statistics for health outcomes in Bordeaux (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			10	154.1			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	0	0.0			
Sudden infant death syndrome *ICD9 798.0 – ICD10 R95*	798.0	R95	1	15.4			
GENERAL POPULATION MORTALITY							
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			12.7	2.1	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			4.3	0.72	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			0.73	0.12	
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					1226.0
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					435.7
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					1412.3

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

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.

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 assessment 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/m³*	*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/m³*	*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/m³*	*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 **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/m³** 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/m³** in all days exceeding this value

1.1.3 Reduction **by 5 μg/m³** 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/m³** (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/m³** (Limit of 1999/30/CE Directive for 2010)

1.2.3 Reduction **by 5 μg/m³** of the annual mean value of PM_{10}

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

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

2.1 Reduction of O_3 daily maximum 8-hour moving average concentrations to **120 μg/m³** in all days exceeding this value (Limit for health protection of 2002/3/CE Directive)

2.2. Reduction **by 10 μg/m³** in the daily maximum 8-hour moving average concentrations.

Findings

Potential benefits of reducing PM_{10} levels in Bordeaux area are given in Table 5.

- Each reduction by 5 µg/m^3 of daily PM_{10} concentrations would delay 0.23 death (95%CI: 0.11 – 0.36) per year in the study area, which is equivalent to an annual rate of 3.54 (95%CI: -10.94 – 18.03). A reduction of daily PM_{10} concentrations to 20 µg/m3 would allow a similar gain, since 0.24 death would be delayed (95%CI: 0.11 – 0.38), i.e. an annual rate of 3.70 (95%CI: -11.10 – 19.49).

- The annual number of postneonatal SIDS deaths attributable to PM_{10} levels higher than 20 µg/m^3 was 0.06 (95%CI: 0.03 – 0.08), which is equivalent to an annual rate of 0.92 deaths per 100,000 (95%CI: -6.47 – 8.32).

- In Bordeaux area, no postneonatal death was attributable to PM_{10} levels higher than 40 µg/m^3 since PM_{10} levels were constantly lower than this value.

- As there was no case of postneonatal respiratory mortality in 2001, no death for this cause could be delayed with a reduction of PM_{10} concentrations.

Table 5. Potential benefits of reducing PM_{10} levels in Bordeaux area. 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	0.23 (0.11 – 0.36)	3.54 (-10.94 – 18.03)
	to 20 µg/m^3	0.24 (0.11 – 0.38)	3.70 (-11.10 – 19.49)
	to 40 µg/m^3	NA**	NA**
Respiratory	by 5 µg/m^3	0 (–) ‡	0 (–) ‡
	to 20 µg/m^3	0 (–) ‡	0 (–) ‡
	to 40 µg/m^3	NA**	NA**
SIDS	by 5 µg/m^3	0.06 (0.03 – 0.08)	0.92 (-6.47 – 8.32)
	to 20 µg/m^3	0.06 (0.03 – 0.08)	0.92 (-6.47 – 8.32)
	to 40 µg/m^3	NA**	NA**
MORBIDITY	**Measured daily levels**		
Cough <18 y		*not available*	
LRS <18 y		*not available*	
Hospital respiratory admissions <15 y	by 5 µg/m^3	5.64 (-1.13 – 11.81)	6.01 (1.05 – 10.97)
	to 20 µg/m^3	4.68 (-0.93 – 9.88)	4.99 (0.47 – 9.51)
	to 50 µg/m^3	0.28 (-0.06 – 0.59)	0.30 (-0.81 – 1.40)

* 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 Douais* was used for each French city.

** not applicable since air pollution levels are lower than the scenario level**.**

‡ in Bordeaux area, there was no case of postneonatal respiratory mortality in 2001

- Short-term HIA of PM_{10} on hospital respiratory admissions were calculated using TEOM PM_{10}, as the corresponding RRs were obtained using TEOM measured values as an assessment of PM_{10} 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/m3 was 4.68 (95%CI: -0.93 – 9.88), which is equivalent to an annual rate of 4.99 deaths per 100,000 (95%CI: 0.47 – 9.51).

Potential short-term benefits of reducing O_3 levels are given in Table 6.

- Each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations of O_3 would delay 7.05 deaths (95%CI: 3.86-11.82) per year in the study area, 3.53 (95%CI: 1.69-5.60) from cardiovascular diseases, and 1.40 (95%CI: 0.92-1.87) from respiratory causes.
- Each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations of O_3 would delay 0.90 (95%CI: -8.11 – 10.81) respiratory hospital admission of people aged between 15 and 64, and 3.23 (95%CI: -1.29 – 7.74) respiratory hospital admissions of people aged 65 and more.

Table 6. Potential benefits of reducing ozone daily levels in Bordeaux area. 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	by 10 µg/m^3	7.05 (3.86 – 11.82)	1.17 (0.31 – 2.03)
	to 120 µg/m^3	0.87 (0.47 – 1.45)	0.14 (-0.16 – 0.45)
Cardiovascular	by 10 µg/m^3	3.53 (1.69 – 5.60)	0.58 (-0.03 – 1.19)
	to 120 µg/m^3	0.44 (0.21 – 0.70)	0.07 (-0.14 – 0.29)
Respiratory	by 10 µg/m^3	1.40 (0.92 – 1.87)	0.23 (-0.15 – 0.62)
	to 120 µg/m^3	0.19 (0.12 – 0.25)	0.03 (-0.11 – 0.17)
MORBIDITY	**Daily 1-h max**		
Emergency room visits for asthma <18 y		*not available*	
	Daily 8-h max		
Hospital respiratory admissions 15-64 y	by 10 µg/m^3	0.90 (-8.11 – 10.81)	0.15 (-0.16 – 0.46)
	to 120 µg/m^3	0.11 (-0.97 – 1.30)	0.02 (-0.09 – 0.13)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	3.23 (-1.29 – 7.74)	3.41 (-0.31 – 7.14)
	to 120 µg/m^3	0.40 (-0.16 – 0.97)	0.42 (-0.89 – 1.73)

Discussion

The different HIAs realised in Bordeaux area showed that reducing air pollution can have a significant impact in term of mortality and morbidity, even in these results have to be interpreted with care. Indeed, whereas mortality data are highly reliable, hospital admission data present a major source of uncertainty because they include both emergency hospital admissions and scheduled hospital admissions which are probably not temporally linked with air pollution. Hence, the numbers of attributable hospital admissions are certainly over-estimated.

In Bordeaux area, O_3 daily maximum 8-hour levels are mostly compliant with target values for 2010 since the value of 120 µg/m^3 has only been exceeded on 18 days in 2001 (i.e. 7% of the period). That is why reducing ozone levels to 120 µg/m^3 in all days exceeding this value would have a small impact since it would avoid less than one death and one hospital respiratory admission per year (see Table 6). However, reduction of daily 8-h max levels of ozone by 10µg/m^3 would induce larger health benefits in terms of mortality since it could allow to delay 7 deaths, of which 3.5 for cardiovascular and 1.4 for respiratory causes.

Concerning PM_{10} levels, they are totally 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), even if the impact is very low because of the few cases occurred in the study area in 2001.

In Bordeaux, a large campaign of health promotion has been initiated in summer 2005 to inform both local decision makers' and the general population of ozone health impact. Results from these HIAs could be used as part of such a campaign to give a quantitative information of health effect of ozone.

Conclusion

Results of these HIAs confirm that air pollution can have a significant health impact even in a city like Bordeaux where target values are mostly respected for both ozone and PM_{10}. Although the numbers of attributable outcomes may seem small, especially when compared to those attributable to other risk factors such as tobacco, they should constitute one more argument to promote measures aiming at reducing air pollutant emissions. Indeed, everyone is exposed to air pollution and the knowledge of health benefits for the population could be a powerful way of motivating changes in individuals comportments.

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