HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Marseille

Summary of main findings for Marseille

In 2001 the PM_{10} annual mean (SD) was 29 (10) µg/m^3 , 31 (11) 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 102 (27), 66 and 154 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 0.7 total post neonatal deaths. Reducing PM_{10} daily mean values to 20 µg/m^3 would prevent 15.6 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 11.2 deaths per year in the general population in the study area, 5.2 from cardiovascular diseases, and 2.6 from respiratory causes. In terms of hospital admissions, this would represent 1.5 respiratory admissions in the adult (15-64 years old) population and 7.2 in the population over 64 years.

Summary of HIA of outdoor air pollution in Marseille 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	11.18	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		5.18	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		2.59	
Total postneonatal mortality	1 month- 1 year	Corrected PM_{10}[3]	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		0.32
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.216 (1.102-1.342)			0
Postneonatal Sudden Infant Death Syndrom Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		0.10
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		7.85
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	O_3 8h max	Summer		1.001 (0.991-1.012)		1.54	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		7.18	

[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

The Marseille study area is situated on Mediterranean coast in the district of Bouches du Rhône and includes five municipalities (Marseille, Allauch, Plan de Cuques, Septèmes les Vallons, les Pennes Mirabeau) representing a total area of 355 km^2. The population of 856 507 inhabitants is characterized by a slightly higher percentage of persons over 65 years old compared to the French population. The study area has a Mediterranean climate with two types of strong prevailing winds, the “mistral” and the south-east wind, allowing the dilution of pollutants, and moderate winds such as the sea breeze and the inland breeze.

The area study includes several transportation infrastructures : an international airport, the first port of France and two highways ending to inner-city of Marseille. The car is the main urban transport mean used and is mainly responsible of pollution levels. The closing down of principal factories within study area would result in an important diminution of SO_2 levels pollution.

In the district, the two main causes of deaths in the general population are cardiovascular diseases (30%) and cancers (28%). However, the frequency is different according to age of the population concerned. Cancer is the first cause for adults under 35 years old and cardiovascular diseases deaths are higher for adults over 65 years old. For the children under 15 years old, 42% of deaths are due to external causes (injuries and poisoning) and 25% to cancers. The main causes of infant mortality are conditions arising during the perinatal period and congenital abnormalities. Sudden infant death syndrome frequency has been decreasing of 75% since prevention measures have been implemented in the beginning of the 90’s.
Concerning hospital admissions in the general population, the three main causes are gastrointestinal diseases, cardiovascular diseases and cancers . For the children under 15 years old, the first cause of hospital admissions is due to respiratory diseases.

Air pollution Health impact assessment (HIA) has 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/m^3 would reduce mortality in the study area by about 170 deaths in one year, which would save about 72 years of expected life for starting year of simulation. If the daily means of PM10 would have been kept under 20 µg/m^3, about 37 deaths, 140 hospital admissions for cardiovascular diseases and 80 admissions for respiratory diseases could have been avoided in the year 2000.

This report presents the results obtained for the Marseille 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 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

The main source of air pollution on the Marseille city is road traffic. The BS pollution is linked for a large part to exhaust emissions from diesel engine vehicles. PM_{10} are mainly linked to road transport (74%), industry and waste management representing 12%. Other sources of PM_{10} are secondary particles, resuspended road dust, sea particles and natural dust (south wind brings particles from Sahara). For the area, 79% of NOx emissions are linked to road transport, 11% to residential/tertiary sector (Source: Airmaraix , data from 1999).
Ozone is a secondary air pollutant. Its formation is the result of complex processes. Nevertheless, sources of primary pollutants has been identified with the ESCOMPTE study[1] :

[1] ESCOMPTE study : Expérience sur Site pour COntraindre les Modèles de Pollution atmosphérique et de Transport d’Emissions.

the emissions of NOx linked to road transport are combined to the emissions of NOx and COV from industrial sources (from the industrial area of Etang de Berre near Marseille city).

Main sources of air pollution in Marseille city

	NOx *(t/year)*	CO *(t/year)*	CO_2 *(kt/year)*	SO_2 *(t/year)*	COVNM *(t/year)*	PM_{10} *(t/year)*	$PM_{2.5}$ *(t/year)*
Transport (road, planes, trains)	79,1%	72,7%	35,9%	11,0%	40,0%	74,4%	73,9%
Residential/tertiary sector	10,9%	11,1%	43,9%	12,6%	19,5%	11,4%	11,8%
Industry/waste management	8,2%	16,1%	16,3%	67,1%	25,2%	12,4%	12,4%
Energy	1,3%	0,1%	3,9%	9,3%	5,1%	1,7%	1,9%
Farming	0,5%	0,0%	0,0%	0,0%	10,3%	0,0%	0,0%
Total emissions	6944	29662	2510	4087	8810	516	468

Source: Airmaraix , data from 1999

Since 1983, SO_2 levels have been strongly decreasing because of the limitation of emissions from factories and heating systems.
NO_2 levels have been decreasing slowly since 1990, especially in most polluted areas but, since 2000, the levels have been stable. PM_{10} levels have been relatively stable since 2000.

The region Provence Alpes Cote d'Azur is one of the most polluted area by ozone in Europe. Ozone levels show an increasing trend since the beginning of the 90's. Ozone levels exceed frequently limit for health protection of the 2002/3/CE Directive (120 µg/m^3) between May and September (one day in three). The highest ozone levels correlated with the most important heat wave for the region has been measured in the summer 2003.

Exposure data

Air pollutants have been monitored by the Marseille air-quality network AIRMARAIX since 1982. Within study area of Marseille 13 stations measured 7 different pollutants in 2001.

Ozone levels for the study area are monitored by two urban background stations (Cinq avenues and Sainte Marguerite),and two suburban stations (Plan de Cuques and les Pennes Mirabeau). Ozone concentrations are measured by Ultraviolet photometric method.

PM_{10} monitoring sites have been set up progressively since 1998. Currently, PM_{10} are measured by three urban background stations (St Louis, Cinq Avenues and Thiers/Noailles) and one traffic station. PM_{10} concentrations are measured by quartz microbalance method (TEOM).

For HIA purpose for chronic exposure, ENHIS recommended to correct TEOM PM_{10} in order to compensate losses of volatile compounds, because the corresponding RRs were obtained using gravimetric PM_{10} as a measure of exposure. In Marseille, as part of the French national pilot program for PM surveillance, specific polynomial regression has been used for each city PM_{10} correction. The coefficients of these regressions were derived from parallel PM_{10} measurements within each city[2]. In Marseille, a sensitivity analysis was conduced in order to assess how the use of this correction factor modified the result of the long-term HIAs. For this purpose, long-term HIAs were conduced using both corrected and non-corrected TEOM PM_{10}.

PM_{10} daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the three urban stations.

Two different indicators for ozone have been calculated: The daily maximum 1-hour indicator has been calculated as the arithmetic mean of the 1-hour maximum of the stations. The daily maximum 8-hour moving average of each day have been calculated as the arithmetic mean of the maximum 8-hour moving averages of the stations for the summer period (1st April to 30th September).

The annual mean level (SD) of TEOM PM_{10} in Marseille was 29 (10) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 15 µg/m^3 and 49 µg/m^3.The annual mean level (SD) of corrected PM_{10} in Marseille was 31 (11) µg/m^3, and P5 and P95 of the daily mean values

[2] 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

were, respectively, 16 µg/m^3 and 53 µg/m^3. The mean (SD) , P5 and P95 of the daily maximum 8-hour moving average concentrations of O_3 were, respectively, 102 (27), 66 and 154 µg/m^3, and those of the daily maximum 1-hour concentrations 91 (40), 34 and 166 µg/m^3 (Table 1 and figures 1-3)

Both TEOM and corrected PM_{10} annual mean were below the limit value for 2005 (40µg/m^3). However, both TEOM and corrected PM_{10} levels were 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 45 days in the year 2001, whereas the target value for 2010 is 120 µg/m3 and should not 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. Twelve days correspond to the situation where the information threshold (180 µg/m^3 for 1-hour average) was overshot.

Daily corrected PM_{10} levels show a smaller variability. During more than 50% of the days, the daily mean value is between 10 and 30 µg/m^3. During slightly less than 14% of the days, the daily mean value is lower than 20µg/m^3.

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

	O3 8h - summer	O3 1h max - year	corrected PM10 - year
Number	183	365	365
Minimum	44	9	9
Percentile 5	66	34	16
Percentile 25	83	64	24
Median	97	88	28
Percentile 75	121	108	38
Percentile 95	154	166	53
Percentile 98	166	187	61
Maximum	185	240	69
Daily mean	102	91	31
standard error	27	40	11
% missing values	0,00%	0,00%	0,00%

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

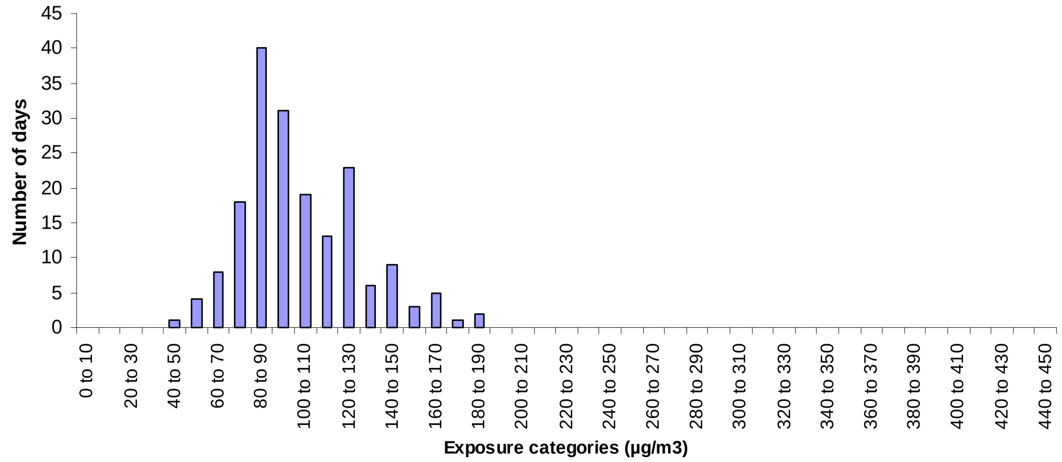


Fig 2. Distribution of O3 1h max in Marseille area- year 2001

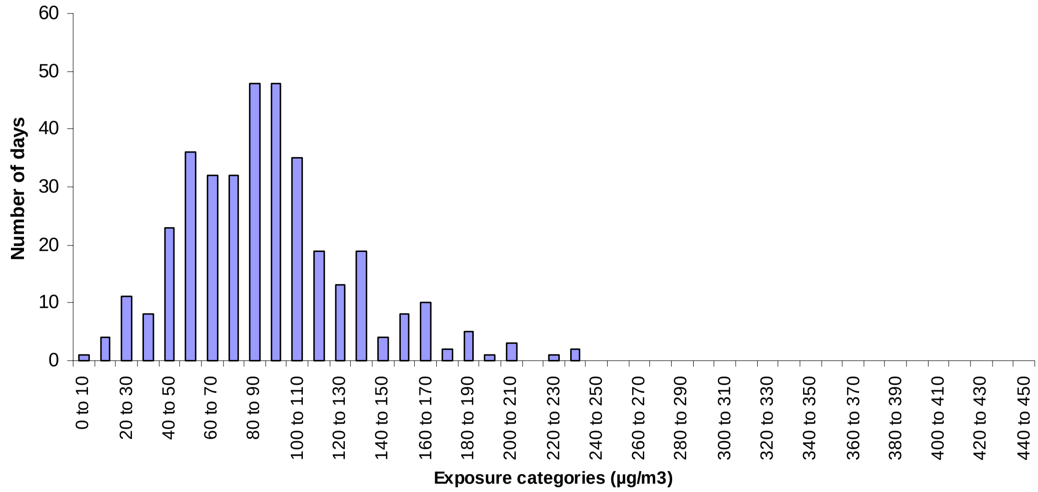
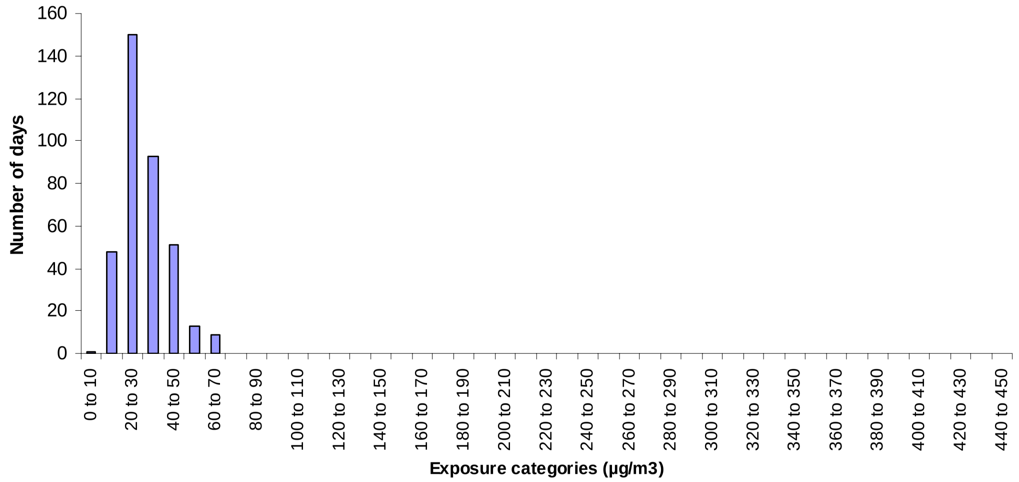


Fig 3. Distribution of corrected PM10 in Marseille area - year 2001



Health data

- **Mortality**

Mortality data were obtained from the CepiDC at the National Health and Medical Research Institute (INSERM). Death causes for year 2001 were coded according to ICD-10. The data were available for year 2001.

The CepiDC department used a quality control programme. The completeness of register was verified by crossing two different sources of data. Since year 2000, the codification of deaths is automated (80%).

- **Hospital admissions**

Data on hospitalisations for respiratory diseases were provided by the Hospital Information Technical Agency (ATIH), from the hospital information system PMSI (Programme de médicalisation des systèmes d'information) for public and private hospitals in Marseille. Respiratory diseases were coded according to ICD-10. Data were available for year 2001.

Data from the hospital information system concerned total admissions. The completeness was quite 100 % and one quality control per year was done. There was no missing data.

- **Others Morbidity data**

Data concerning cough, lower respiratory symptoms and emergency room visits for asthma were not available on Marseille study area hence HIA has not been conduced.

The total number of postneonatal deaths in 2001 was 14 (annual rate 145.2 per 100,000) , among which 2 were due to sudden infant death syndrome.

The number of deaths in the general population (excluding external causes) was 7041 (annual rate 864 per 100,000), among which 2344 (annual rate 274 per 100,000) were due to cardiovascular causes, and 507 (annual rate 59 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 1048 per 100,000, and annual rate among people aged 65 and more was 1955 per 100,000. The annual rate for people age between 15 and 64 was really lower : 564 per 100,000.

Table 2. Descriptive statistics for health outcomes in Marseille area, 2001

Health outcome	ICD9	ICD10	Annual number	Annual rate (per 100 000)	Daily mean (SD)	Daily rate (per 100 000)
POSTNEONATAL MORTALITY						
Total			14	145.2		
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	20.7		
GENERAL POPULATION MORTALITY						
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			20.28 (4.94)	2.37
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			6.42 (2.65)	0.75
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			1.39 (1.16)	0.16
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				2.87
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99				1.55
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99				5.36

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[3] 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[4].

[3] 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:

[4] 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

In Marseille study area, postneonatal mortality is low and respiratory postneonatal mortality is null, hence the results obtained from HIA are very small. The annual number of postneonatal deaths attributable to corrected PM_{10} levels higher than 20 µg/m^3 was 0.69 (95%CI: 0.32 – 1.08), which is equivalent to an annual rate of 0.72 deaths per 100,000 (95%CI: 0.33 – 1.13).

The annual number of postneonatal SIDS deaths attributable to corrected PM_{10} levels higher than 20 µg/m^3 was 0.21 (95%CI: 0.12 – 0.30), which is equivalent to an annual rate of 0.22 deaths per 100,000 (95%CI: 0.13 – 0.31).

Short-term HIA of PM_{10} on hospital respiratory admissions for children 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 under 15 years old attributable to PM_{10} levels higher than 20 µg/m^3 was 15.59 (95%CI: -12.66 – 133.85), which is equivalent to an annual rate of 10.13 admissions 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	**Annual mean levels**		
Total	by 5 µg/m^3	0.32 (0.15 – 0.50)	0.33 (0.15 – 0.52)
	to 20 µg/m^3	0.69 (0.32 – 1.08)	0.72 (0.33 – 1.13)
	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	0.10 (0.06 – 0.14)	0.10 (0.06 – 0.15)
	to 20 µg/m^3	0.21 (0.12 – 0.30)	0.22 (0.13 – 0.31)
	to 40 µg/m^3	NA	NA
MORBIDITY	**Daily levels**		
Cough <18 y	by 5 µg/m^3	Not available	
	to 20 µg/m^3	Not available	
	to 50 µg/m^3	Not available	
LRS <18 y	by 5 µg/m^3	Not available	
	to 20 µg/m^3	Not available	
	to 50 µg/m^3	Not available	
Hospital respiratory admissions <15 y	by 5 µg/m^3	7.85 (-1.57 – 16.44)	5.10 (-1.02 – 10.69)
	to 20 µg/m^3	15.59 (-3.10 – 32.89)	10.13 (-2.02 – 21.38)
	to 50 µg/m^3	0.38 (-0.08 – 0.80)	0.25 (-0.05 – 0.52)

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

Regarding short-term effects of O_3, a reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 11.2 (95%CI: 6.13 – 18.75) deaths per year in the study area, 5.2 (95%CI: 2.48 – 8.22) from cardiovascular diseases, and 2.6 (95%CI: 1.70 – 3.46) from respiratory diseases.

Each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 1.5 (95%CI: -13.86 – 18.49) respiratory hospital admissions of people aged between 15 and 64, and 7.2 (95%CI: -2.87 – 17.22) 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	by 10 µg/m^3	11.18 (6.13 – 18.75)	1.31 (0.72 – 2.19)
	to 120 µg/m^3	5.72 (3.13 – 9.62)	0.67 (0.36 – 1.12)
Cardiovascular	by 10 µg/m^3	5.18 (2.48- 8.22)	0.60 (0.29 – 0.98)
	to 120 µg/m^3	2.70 (1.29 – 4.30)	0.32 (0.15 – 0.50)
Respiratory	by 10 µg/m^3	2.59 (1.70 – 3.46)	0.30 (0.20 – 0.40)
	to 120 µg/m^3	1.46 (0.95 – 1.97)	0.17 (0.11 – 0.23)
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	1.54 (-13.86 – 18.49)	0.28 (-2.52 – 3.36)
	to 120 µg/m^3	0.77 (-6.83 – 9.34)	0.14 (-1.24 – 1.70)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	7.18 (-2.87 – 17.22)	4.68 (-1.87 – 11.24)
	to 120 µg/m^3	3.76 (-1.49 – 9.10)	2.45 (-0.97 – 5.93)

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

Discussion

Mortality data are highly reliable, and therefore 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 planned hospital admissions, that are certainly not temporally linked with the levels of air pollution. In consequence, the numbers of attributable hospital admissions are certainly over-estimated.

In Marseille 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). 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-hours max levels of ozone by 10µg/m^3 would induce health benefits in terms of mortality (respectively 11.2, 5.2 and 2.6 for total, cardiovascular and respiratory mortality).

PM_{10} levels are compliant with 2005 limit value. Thus, there are no attributable cases for the scenario corresponding to a reduction of the annual mean to 40µg/m^3. The compliance with 2010 limit value for PM_{10} would induce a small benefit for the postneonatal mortality. On the other hand, the health benefits would be more important on respiratory hospital admissions for children (16 admissions per year corresponding to an annual rate of 10.13 per 100,000).

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.

French policy on air pollution is defined by the law on air and the rational use of energy voted on December 1996. This law requires monitoring of air quality and its effects on health, to define quality objectives and inform the general public. It is based on different plans :

The regional plan for air quality (PRQA) approved on 2000, sets guidelines to prevent or reduce air pollution. It aims to reduce the levels of pollutant concentrations in a given area to less than the European policies. It should have been reconsidered in 2005 but, has been postponed because of the transfer of abilities from state administration to regional administration.

The plan for air protection (PPA) aims to take the necessary measures in order to follow the European policy on regulated pollutants such as SO_2, NO_2, PM10, CO, Pb, HCl, O_3, C_6H_6. Yet, if necessary, local policies on regulated pollutants may be more restrictive than the European policies and new measures on non-regulated pollutants may also be taken. The PPA is in progress to be approved.

The urban travelling plan (PDU) for Marseille, approved on 2000, aims to take new developments in the city, until 2015, that would allow the reduction of cars traffic, the improvement of public transports (tramway and subway) and the reduction of pollutants emissions and noises.

Since the summer 2004, a regional plan for limitation of ozone peaks has been recommending the use of graduate measures according to different limit values of ozone (180, 240, 300, 340 $\mu g/m^3$) in order to limit the emissions from traffic, industrial and domestic sources of primary pollutants and in order to protect the health of population living in the polluted area.

The air quality network carries out maps of pollution episodes by ozone and forecasting maps of ozone levels for the two next days, available for consultation every days on its website.

Since year 2000, several HIAs according to the methodology recommended by the French programme for air pollution effects surveillance (PSAS-9) have been conduced in the most important cities of the region. The benefits in term of attributable cases induced by different scenarios of pollution reduction have been given to the decision makers. The results has been included in some PPA.

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 comportments.

At the local level, results of ENHIS complete the PSAS-9 results for PM and ozone HIA and local policies repercussions of these programmes.

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