HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

LE HAVRE

Summary of main findings for Le Havre

In 2001 the PM_{10} *annual mean (SD) was 21 (9) µg/m*^{3}*, 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 80 (23), 53 and 134 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 0.15 total postneonatal deaths. Reducing* PM_{10} *daily mean values to 20 µg/m*^{3} *would prevent 3.6 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 3.2 deaths per year in the general population in the study area, 1.3 from cardiovascular diseases, and 0.8 from respiratory causes. In terms of hospital admissions, this would represent 0.4 respiratory admissions in the adult population and 1.8 in the population over 64 years*.

Summary of HIA of outdoor air pollution in Le Havre in ENHIS-1

Health outcome	Population	Pollutant	Period	Mean type	RR (for 10 µg.m³ increase)	*References*	Number of attributable cases by scenario[1]	
Mortality							**Ozone: Reduction by 10 µg.m³**	**PM_{10}: Reduction by 5 µg/m³**
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	5.39	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		2.54	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		1.10	
Total postneonatal mortality	1 month-1 year	Corrected PM_{10}[3]	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		0.19
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		0.11
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		5.22
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)		0.46	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		2.64	

[1] For ozone: absolute reduction by 10 µg/m³. For PM_{10} absolute reduction by 5 µg/m³.

[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 metropolitan area of Le Havre is 199 km^2 size with a population of approximately 255 000 inhabitants, whose 15% older than 65 years (INSEE, 1999 census). It is on the right bank of the Seine estuary, 90 km from Rouen and 220 km from Paris. The study area includes 16 municipalities. It has an oceanic climate with minimum and maximum temperatures of, respectively ,7.9°C and 13.2°C.
  The industrial area is very near the city, also main causes of air pollution in the city are industry and traffic. Industrial emissions, like SO_2, show a trend toward a decrease over the last years, but levels of pollutants near industries are above limit values. Levels of PM_{10} are stable and ozone levels vary from one year to the next according to the sunning. To decrease pollution, two political framework organize the public air quality management: the regional plan for air quality (PRQA) and the plan for air protection (PPA) for Le Havre's agglomeration which will be finished to write in 2006.
- in Le Havre's study area, main causes of mortality are cardiovascular diseases and cancers bronchopulmonary. The main causes of infant mortality are conditions arising during the perinatal period and congenital anomalies.
- Previous health impact assessments (HIA) of air pollution were conducted for the European program APHEIS and the French program PSAS-9, and were in favour of the measures taken to reduce emissions. The analysis of APHEIS 3 have estimated that reduction of the long-term PM pollution to the levels of $PM_{2.5}$ of 15 µg/m^3 would reduce mortality in Le Havre by 17 deaths in one year, which would save 6 years of expected life for starting year of simulation. If the daily means of PM_{10} have been kept under 20 µg/m^3, 4 deaths and 16 respiratory and cardiac hospital admissions could have been avoided in the year 2000. In PSAS-9 report, the analysis show that a reduce of 10% of air pollution would save about 8 deaths.
- To complete these results, this report presents HIA results obtained for Le Havre 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 table show the distribution of air pollution's sources in the region of Haute-Normandie (inventory emissions of Haute-Normandie 2000).

Table 1. Main sources of air pollution

Source	Industry (%)	transport (%)	Residential/ tertiary sector (%)	Agriculture (%)
SO2	92%	4%	2%	2%
NOx	35%	38%	2%	25%
PM_{10}	48%	31%	16%	5%

Principal sources of air pollution were traffic and industry. Le Havre's share of regional air pollution emissions is estimated at 44% for sulfur dioxide (SO_2), 21 % for nitrogen dioxide (NO_2)

and 13% for PM_{10}. Ozone levels depend on sunning and other pollutants like NO_2 and VOC (volatile organic component) which are mainly produced by traffic.

Exposure data

- A permanent automated air pollution network (Air Normand) provides air pollution data. The agglomeration is covered by 13 fixed stations including 6 urban. Ozone is measured in 3 stations by UV adsorption method. PM_{10} are measured since 2000 in 3 stations, by automatic analyser TEOM (Tapered Element Oscillating Microbalance).
- How indicators have been calculated:

  The stations used to construct pollution indicators were selected in the city area according to the following criteria: the ambient urban stations had to be correlated (correlation >= 0.70) and to present close mean levels of pollution. For PM_{10} and O_3, three urban stations were selected.

  - PM_{10}: daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the stations. For HIA purpose for chronic exposure, ENHIS recommended to correct TEOM PM_{10} in order to make up for losses of volatile compounds, because the corresponding RRs were obtained using gravimetric PM_{10} as a measure of exposure. In Le Havre, 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 measurements within each city[1].
  - 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 PM_{10} in Le Havre was 21 (9) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 12 µg/m^3 and 40 µg/m^3.
  The annual mean level (SD) of corrected PM_{10} in Le Havre was 24 (10) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 13 µg/m^3 and 47 µg/m^3.
  The mean (SD) , P5 and P95 of the daily maximum 8-hour moving average concentrations of O_3 in summer were, respectively, 80, 53 and 134 µg/m^3, and those of the daily maximum 1-hour concentrations (entire year) 71, 27 and 141 µg/m^3 (Table 1 and figures 1-3).

  In 2001 the PM_{10} annual mean (21 µg/m^3) was above the 1999/30/EC Directive limit value for 2010 (20 µg/m^3), but below that established for 2005 (40 µg/m^3).

  The figures 1, 2 and 3 represent the distributions of levels of the 3 indicators: O_3 8h, O_3 1h and PM_{10}. Levels most often present were between 50 and 90 µg/m^3 for ozone 8h in summer and between 10 and 30 µg/m^3 for corrected PM_{10} in year 2001. Maximum Ozone 8h levels were higher than 120 µg/m^3 during 23 days in 2001 and respect thus target value for 2010 (120 µg/m^3 not to be exceeded on more than 25 days per calendar year averaged over three years). The directive limit value for 2010 for PM_{10} was exceeded 45% of the days in 2001.

[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

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

	O3 8h - summer	O3 1h max - year	Corrected PM_{10} - year
Number	183	365	365
Minimum	42	5	8
Percentile 5	53	27	13
Percentile 25	62	58	16
Median	77	69	21
Percentile 75	88	86	28
Percentile 95	134	121	47
Percentile 98	144	151	54
Maximum	157	193	90
Daily mean	80	72	24
standard error	23	28	11
% missing values	0,00%	0,00%	0,00%

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

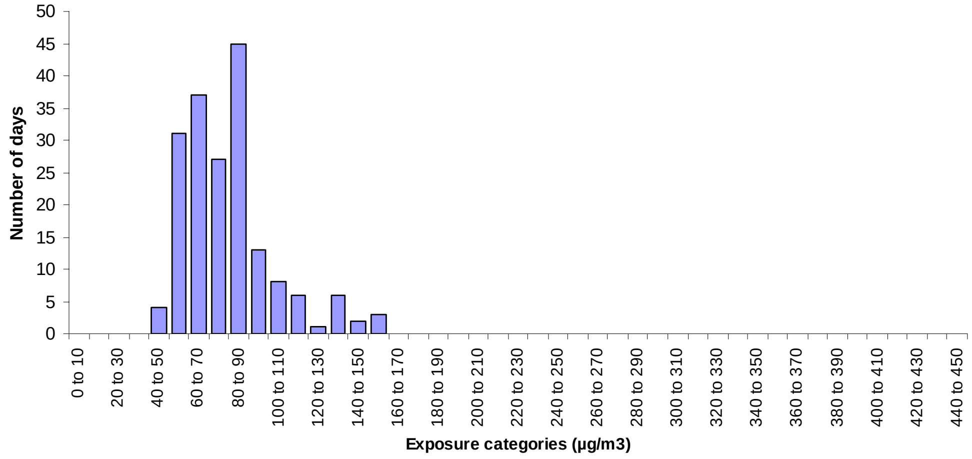


Fig 2. Distribution of O3 1h max in Le Havre area - year 2001

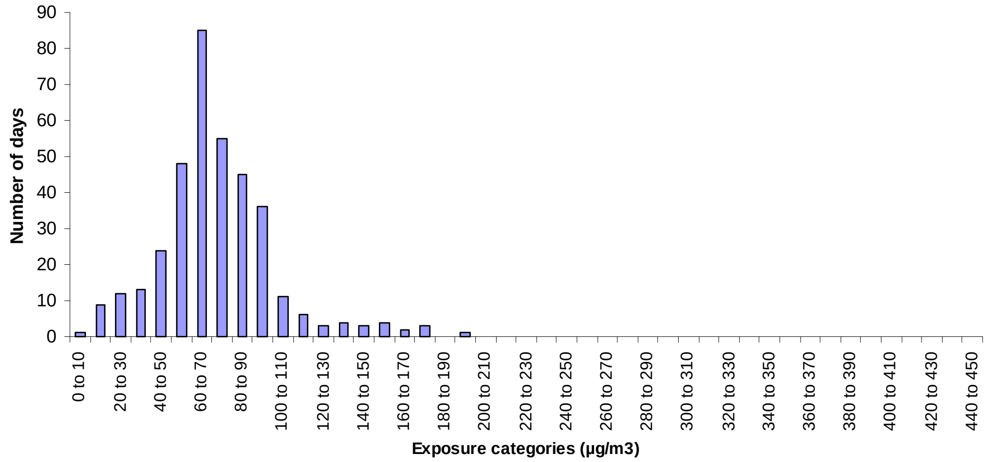
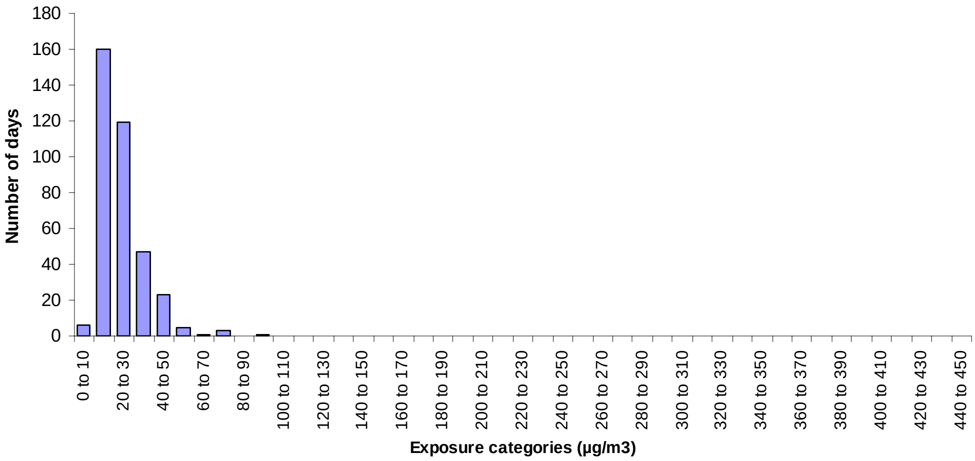


Fig 3. Distribution of PM10 in Le Havre area - year 2001



Health data

- Mortality data were provided by the Information Department specialised in mortality data (CepiDC) at the National Health and Medical Research Institute (INSERM) for year 2001. 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 for respiratory diseases were extracted by the French Institute of Public Health (InVS) from the hospital information system PMSI (Programme de médicalisation des systèmes d'information) for public and private hospitals in Le Havre. Respiratory diseases are coded with ICD10 and available for year 2001.

- Data concerning specifically emergency hospital admissions, emergency room visit for asthma, cough or lower respiratory syndromes were not available for Le Havre study area, and hence no HIA was conduced for these indicators.

Description of the health outcomes analyzed for HIA are shown in Table 2 in terms of number of cases and rates per 100 000.

Table 2. Descriptive statistics for health outcomes in Le Havre 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			8	257			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	0	-			
Sudden infant death syndrome *ICD9 798.0 – ICD10 R95*	798.0	R95	2	64			
GENERAL POPULATION MORTALITY							
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			5.7 (2.4)	2.2	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			1.6 (1.2)	0.6	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			0.4 (0.7)	0.2	
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	not available	
Hospital respiratory admissions - Age < 15 years *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99					1 479.8
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					472.7
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					1 880.6

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) ↑$10 \mu g/m^3$	Lacasaña et al 2005
	Postneonatal respiratory mortality ICD9 460-519 ICD10 J00-J99	**PM_{10}** Annual Mean	RR=1.216 (1.102-1.342) ↑$10 \mu g/m^3$	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) ↑$10 \mu g/m^3$	Woodruff et al. 1997
	Cough	**PM_{10}** Daily Mean	OR=1.041 (1.020-1.062) ↑$10 \mu g/m^3$	Ward & Ayres 2004
	Lower respiratory symptoms LRS	**PM_{10}** Daily Mean	OR=1.041 (1.020-1.051) ↑$10 \mu g/m^3$	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) ↑$10 \mu g/m^3$	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) ↑$10 \mu g/m^3$	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) ↑$10 \mu g/m^3$	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) ↑$10 \mu g/m^3$	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)* ↑$10 \mu g/m^3$	*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)* ↑$10 \mu g/m^3$	*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)* ↑$10 \mu g/m^3$	*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/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

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/m³** in all days exceeding this value (Information threshold of 2002/3/CE Directive)

1.2.1.2 Reduction **by 10 μg/m³** 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/m³** in all days exceeding this value (Limit for health protection of 2002/3/CE Directive)

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

Findings

The annual number of postneonatal deaths attributable to PM_{10} levels higher than 20 μg/m³ was 0.15 (95%CI: 0.04 – 0.13), which is equivalent to an annual rate of 4.73 deaths per 100 000 (95%CI: 0.72-2.40).

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	**Annual mean levels**		
Total	by 5 µg/m^3	0.19 (0.09 – 0.29)	5.95 (2.75 – 9.24)
	to 20 µg/m^3	0.15 (0.07 – 0.23)	4.73 (2.18 – 7.33)
	to 40 µg/m^3	NA	NA
Respiratory	by 5 µg/m^3	0.00	0.00
	to 20 µg/m^3	0.00	0.00
	to 40 µg/m^3	NA	NA
SIDS	by 5 µg/m^3	0.11 (0.07 – 0.15)	3.53 (2.25 – 4.82)
	to 20 µg/m^3	0.09 (0.05 – 0.12)	2.89 (1.61 – 3.85)
	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	3.59 (-0.72 – 7.51)	7.26 (-1.40 – 15.21)
	to 20 µg/m^3	2.94 (-0.59 – 6.21)	5,96 (-1.19 – 12.57)
	to 50 µg/m^3	0,10 (-0.02 – 0.21)	0,20 (-0.04 – 0.42)

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

Regarding short-term effects of O_3, each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 3.15 (95%CI: 1.73 – 5.28) deaths per year in the study area, 1.28 (95%CI: 0.61 – 2.03) from cardiovascular diseases, and 0.8 (95%CI: 0.53 – 1.07) from respiratory causes.

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)**
Emergency room visits for asthma <18 y	by 10 µg/m^3	not available	not available
	to 180 µg/m^3	not available	not available
MORTALITY	**Daily 8-h max**		
Total	by 10 µg/m^3	3.15 (1.73 – 5.28)	1.24 (0.68 – 2.07)
	to 120 µg/m^3	0.47 (0.26 – 0.70)	0.19 (0.10 – 0.31)
Cardiovascular	by 10 µg/m^3	1.28 (0.61 – 2.03)	0.50 (0.24 – 0.80)
	to 120 µg/m^3	0.20 (0.09 – 0.31)	0.08 (0.04 – 0.12)
Respiratory	by 10 µg/m^3	0.80 (0.53 – 1.07)	0.32 (0.21 – 0.42)
	to 120 µg/m^3	0.13 (0.09 – 0.18)	0.05 (0.03 – 0.07)
MORBIDITY	**Daily 1-h max**		
	Daily 8-h max		
Hospital respiratory admissions 15-64 y	by 10 µg/m^3	0.39 (-3.54 – 4.71)	0.24 (-2.12 – 2.82)
	to 120 µg/m^3	0.06 (-0.51 – 0.70)	0.03 (-0.31 – 0.42)
Hospital respiratory admissions > 64 y	by 10 µg/m^3	1.75 (-0.70 – 4.19)	4.55 (-1.82 – 10.93)
	to 120 µg/m^3	0.27 (-0.11 – 0.65)	0.70 (-0.28 – 1.69)

Discussion

- In order to decrease potential exposure misclassification, the study area was defined using population exposure homogeneity criteria : this area doesn't present any discontinuance in urbanization, the work-place of the majority of working inhabitants was located in the area and, air pollution data homogeneity (close means and high correlation coefficients) was checked on multi-sites measurements time series. For PM10 levels, the correction factors must be used cautiously because the proportion of volatile matter within the particles varies according to multiple factors (meteorological conditions, chemical composition of particles…). The use of new methods of measurement (Sampler equilibration system, for example) avoiding loss of volatile matter might be a better way of assessing PM10 exposure for the purpose of long-term HIA.
- Mortality data are highly reliable and hence don't represent a major source of uncertainty for the results of the present HIAs. The principal source of uncertainty of health data lies in hospital admissions data. Indeed these data correspond to total admissions and not only emergency admissions due to the registry organisation. It can lead to overestimate the health impact assessment because included planned admissions can't be related to exposure.
- In Le Havre study area, daily ozone 8-h max levels were higher than 120 µg/m^3 during 12 days in 2001 and respect thus target value for 2010 (120 µg/m^3 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 0.47, 0.20 and 0.13, 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 more health benefits in terms of mortality (respectively 3.15, 1.28 and 0.80 for total, cardiovascular and respiratory mortality).
- PM_{10} levels are below the 2005 limit values (40µg/m^3) but above that planed for 2010 (20µg/m^3). Thus, there are no attributable cases for the scenario corresponding to a reduction of the annual mean to 40µg/m^3, but there is attributable postneonatal deaths for both a reduction of the annual mean by 5µg/m^3 (5 per 100 000) and a reduction of the annual mean to 20µg/m^3 (2010 limit value). This number can appear small because infant mortality is quite low in Le Havre, like in Europe (8 deaths for 2001). However, the results show that the compliance with 2010 limit value for PM10 would certainly induce health benefits in the study area.
- The number of attributable cases may seem small when it's 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 easier to control at the individual scale.

Conclusion

These results complete those presented in the report Apheis 3 for the agglomeration of Le Havre with an estimation of the impact of particles PM_{10} and Ozone. They confirm that medical profits can be potentially obtained by the improvement of the quality of the air even in cities where the air pollution is right now moderate.

The results from the present HIAs will allow to sensitise the decision makers and general public with the impact of the air pollution, and particularly PM_{10} on the young children's health. This impact, even weak, is significant and cannot thus be neglected. It may help promoting measures aiming at reducing air pollutant emissions, especially traffic which takes part in majority in the production of ozone. There results and those stem from the European program APHEIS and the French program PSAS-9, were used for the PPA of Le Havre.

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 postneonatal 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