APHEIS

Air Pollution and Health: A European Information System

Health Impact Assessment of Air Pollution

Lyon City Report

2002-2003

July 2004

LYON CITY REPORT PLAN

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LYON CITY REPORT

Summary of the main findings

The metropolitan area of Lyon has kept its vocation of river, railway and road crossings considering its geographical location in the Rhone Valley. A continental climate with anticyclonic conditions of temperature inversion in winter is commonly encountered in the city. The study area includes 9 municipalities around Lyon with 782 828 inhabitants (15,7% of whom are more than 65 years) spread out on 132 km² of land (density of 5930 inhab./km²). The concentrations of air pollutants have been steady levels since 1993, excepted for SO_2 which decreased consistently and NO_2 showing a slight reduction since 1997.

TEOM and filtromat techniques are to measure PM_{10} and BS respectively. According to a metrological study carried out in 12 French cities during the winter of 2001/2002 and summer 2001, PM_{10} measures with TEOM were compared with those of PARTISOL. A conversion factor of 1.221 to compensate losses of volatile PM_{10} was used in winter. No measures were available for $PM_{2.5}$ and a conversion factor from PM_{10} to $PM_{2.5}$ of 0.7 was used.

Age-standardised total mortality rate (ICD9 = [000-999]) was 663.7 per 100,000 inhabitants. For short term health impact assessment, the mortality from cardiovascular, cardiac and respiratory disease represent 34.0%, 22.8% and 7.9% of the total mortality, respectively. Cardiac and respiratory hospital admissions had a similar daily mean. For long term HIA, the mortality from cardiopulmonary and lung cancer disease accounted for 36.3% and 5.5% of the total mortality respectively.

In short term HIA, daily reduction of air pollutants levels from above 20 to 20 $\mu g.m^{-3}$ represents the best scenario for PM (PM_{10} and $PM_{2.5}$) and BS. The 2010 limit seems more effective to obtain a maximal impact on mortality by reducing air pollution.
For long term HIA, a reduction by 5 or 3.5 $\mu g.m^{-3}$ in the annual mean value of respectively PM_{10} or $PM_{2.5}$ lead to the best reduction of mortality.
A reduction by 3.5 $\mu g.m^{-3}$ would be the most efficient strategy: 60 lives would be saved and life expectancy would be increased by 0.13 years among people older than 30 years.
Furthermore, the daily improvement of air quality seems to be more efficient in terms of health impact than solely on management of air pollution peaks.

If the quality of air surveillance is now strongly implemented and a real awareness of the air pollution problem is obvious, health measures are currently limited to some measures taken to reduce pollution peak. As decision makers expect more evidence from health studies, the current results of this health impact assessment could be a useful tool in policy decision making for the different actors involved in the management of air pollution. Introducing the results in the decision making circuit and showing these results under pedagogic, understood and suitable ways represent the big challenge to reach by PSAS-9 and APHEIS programs in Lyon city.

Background

Previous HIA for Lyon city (in APHEIS Second Year Report 2000 - 2001) showed a non-negligible benefit for two strategies reducing annual mean levels of PM_{10} to 20 and 10 $\mu g.m^{-3}$ avoiding respectively 73 and 298 deaths. Health impact assessment was extended to two cities and Lyon's Plan for Atmospheric Protection (PPA) was developed.

The metropolitan area of Lyon has kept its vocation of river, railway and road crossings considering its geographical location in the Rhone Valley.

A continental climate with anticyclonic conditions of temperature inversion in winter is commonly encountered in the city. Daily mean temperatures range from 8°C in winter to 17°C in summer. The colder months were January, February and March for the year 2002, with respectively 16, 1 and 2 days below 0°C. Conversely, June, July and August were the warmest months with respectively 14, 12 and 15 days above 25°C. The minimum relative humidity is 52%. Rainy months were essentially May, August and November with respectively 13, 13 and 19 days of rainfall above 0.5 mm. Wind speed greater than 3 $m.s^{-1}$ occurred at least 5 days per month in February, March, September, October and December.

The study area includes 9 municipalities around Lyon with 782 828 inhabitants (15,7% of whom are more than 65 years) spread out on 132 km² of land (density of 5930 inhab./km²). Lyon city counts every day 4,400,000 moves on average which increases by 25% every 10 years. In 1999, an average of 600,000 vehicles penetrated Lyon each day, among them 100,000 and 90,000 cross the Fourvière and Croix-Rousse tunnels respectively and 200,000 come from both the South and North express roads. Indeed, this is explained by the fact that the study area employs about 400,000 people, 60% of whom do not live within it. On the other hand, more than 50% of the 320,000 people live within the study area, but work outside this area.

Lyon's Plan for Atmospheric Protection (PPA) intends to take the necessary measures to abide by the European policy on regulated pollutants such as SO_2, NO_2, PM_{10}, CO, Pb, HCl, O_3, C_6H_6. Yet, if necessary, local policies on regulated pollutants may be more restrictive than the European policies of new measures on non-regulated pollutants may also be implemented.

At the local level, results of Apheis3 complete the PSAS-9 results (French surveillance program for air pollution effects) for health assessment and the impact of these local policies programs.

Sources

Sixty percent of sulphur emissions come from industries (mainly the Feyzin refinery in the Rhone valley) and 60% of nitrogen and carbon monoxide from road traffic.
Finest particles are also linked to road traffic. PM_{10} mean levels have not changed: 29 $\mu g.m^{-3}$ in 1996, 32 $\mu g.m^{-3}$ in 1997, 27 $\mu g.m^{-3}$ in 1998, 23 $\mu g.m^{-3}$ in 1999, 2000 and 2001, 27 $\mu g.m^{-3}$ in 2002.
Similarly, levels of NO_2 and O_3 are constant.
A high mean level of ozone has been observed more in mountainous regions or during the last hot summer of 2003.

An updated inventory of pollutant sources will be obtained during the year 2004.

Exposure data

TEOM and filtromat techniques are to measure PM_{10} and BS respectively. According to a metrological study carried out in 12 French cities during winter 2001/2002 and summer 2001, PM_{10} measures with TEOM were compared with those of PARTISOL. A conversion factor of 1.221 to compensate losses of volatile PM_{10} was used in winter. No measures were available for $PM_{2.5}$ and a conversion factor of 0.7 from PM_{10} to $PM_{2.5}$ was used.

The results of main pollutants concentrations according to the number of measuring stations are recapitulated in the following table in the study area for the year 2002.

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

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

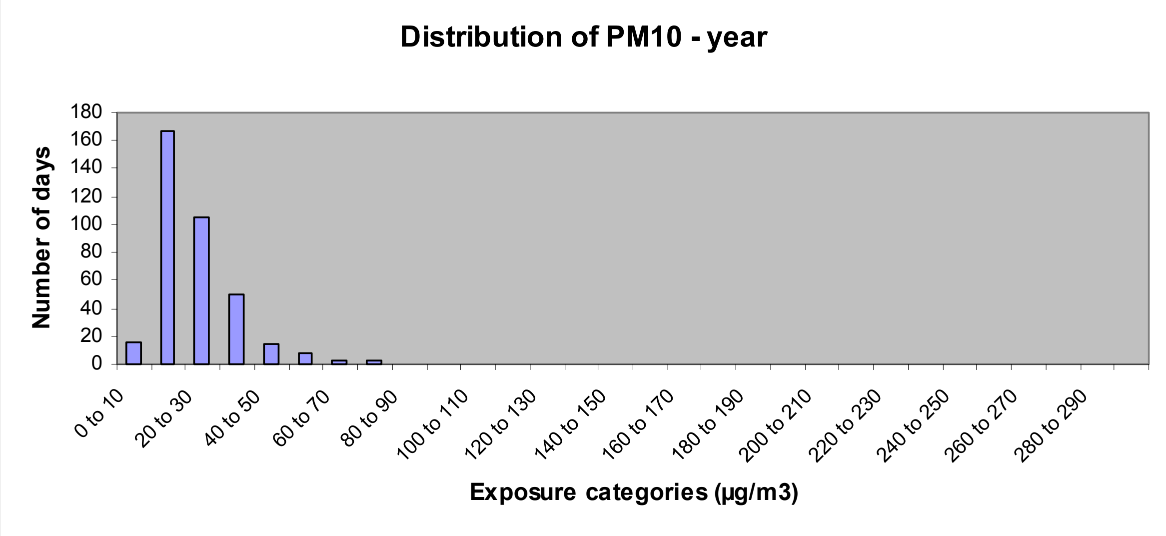
From 1993 to 1999, PM_{10} were measured by 4 stations and after 1999 by 2 stations.
Since 2001, $PM_{2.5}$ is measured by 2 stations: one urban station (Croix-Luizet) and one traffic station (La Mulatière).
Time trends in the concentrations of each air pollutant could be interpreted as follows:

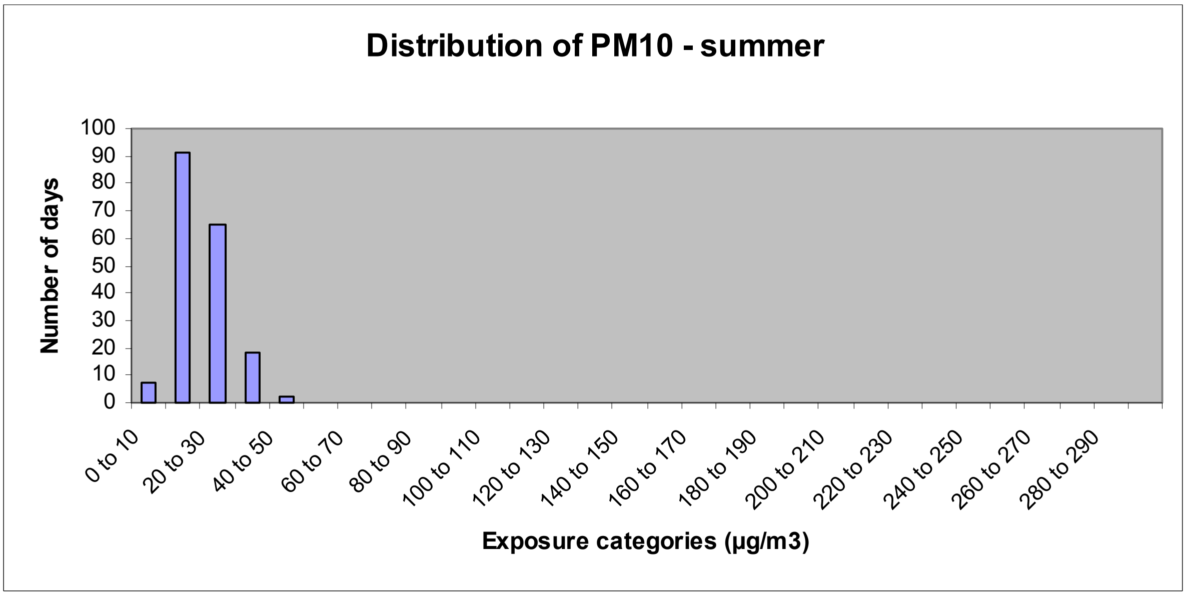
- SO_2: since 1993, this pollutant decreased consistently from an annual average of 42 to less than 10 $\mu g.m^{-3}$ in 2002.
- NO and NO_2 have remained almost at the same level since 1993. Nevertheless, for NO_2, the part due to the traffic has slightly decreased since 1997 from about 70 to less than 60 $\mu g.m^{-3}$.
- Ozone has not shown any evolution in its concentrations, with an annual average of 40 $\mu g.m^{-3}$.
- PM_{10} has remained unchanged since 1995, with an annual average of about 27 $\mu g.m^{-3}$.
- CO measurements show encouraging results with a decreasing trend observed since 1993. Concentrations have fallen from about 3000 to 1000 $\mu g.m^{-3}$ since 2000.
- Heavy metals such as lead or cadmium have decreased since 1995 from 0.25 to less than 0.05 $\mu g.m^{-3}$ in 2002.
- Benzo(a)pyrene is being measured since the end of 2001. The annual average is currently around 0.8 $ng.m^{-3}$, below the future threshold of 1.

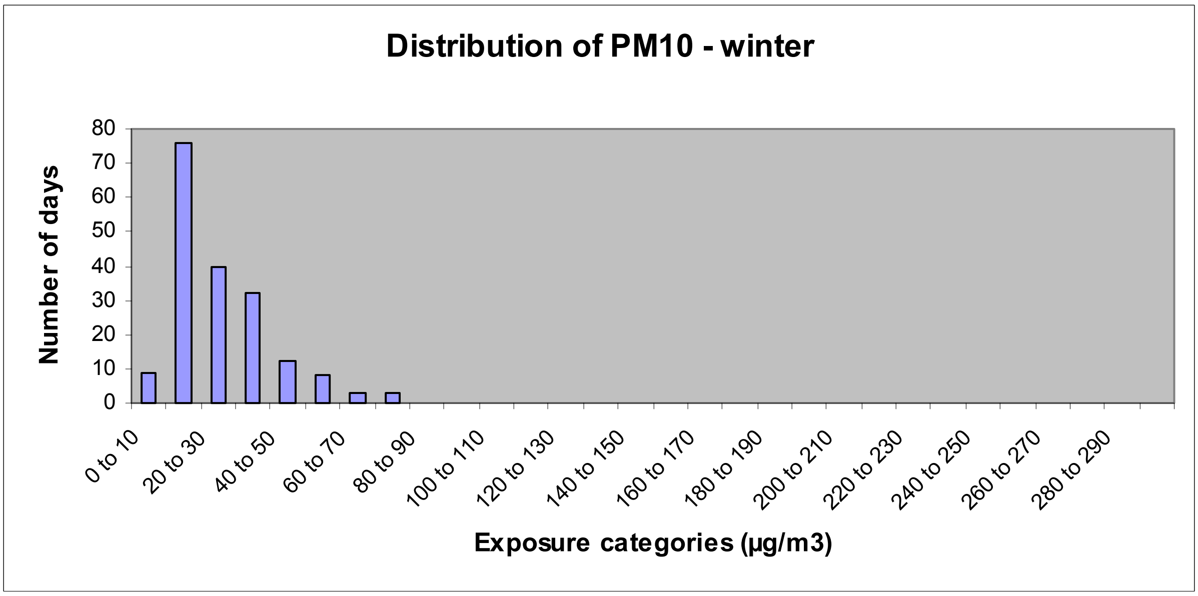
Exposure data for Apheis 3 concerns air pollution data collected in the year 2000. Global descriptive results are in table 2:

	BS	**PM_{10}**
Year of measure	2001	2000
Mean (SD)	48 (20.6)	23.0 (11.7)
Percentiles: 5th - 95th	20 - 87	10 - 45
Number days above 20 µg.m^{-3} (ST - LT)	308	175 - 196
Number days above 50 µg.m^{-3} (ST)	122	14
Number days above 40 µg.m^{-3} (LT)		46

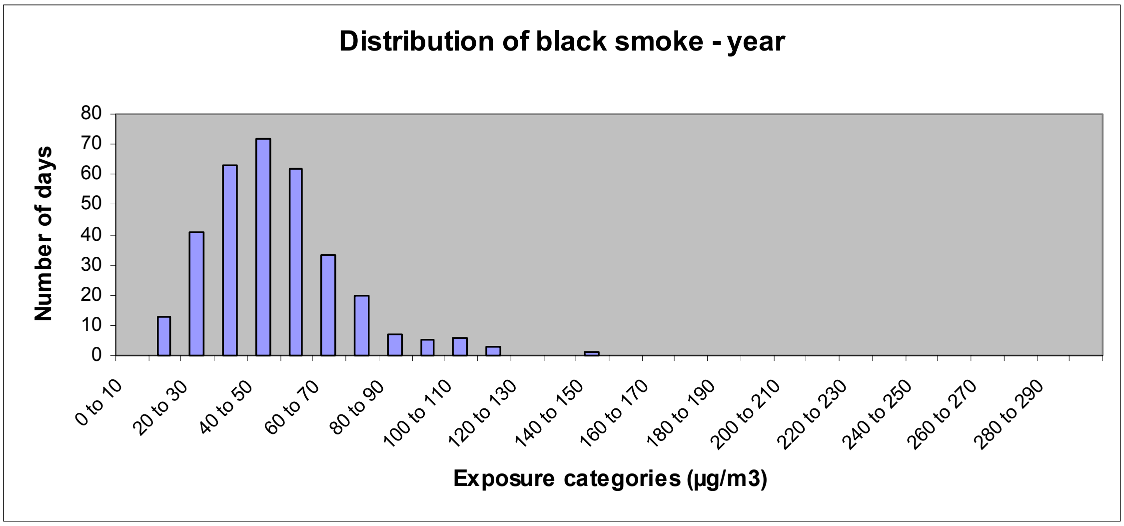
The comparative graph with annual mean levels and percentiles of the distribution of pollutant by station in Apheis 2 and 3 was not possible (figure 1 not available)
The 3 following figures show distributions of PM_{10} during the year, in summer and in winter. The distribution of PM_{10} concentrations are larger in winter than in summer as from the 75th percentile.

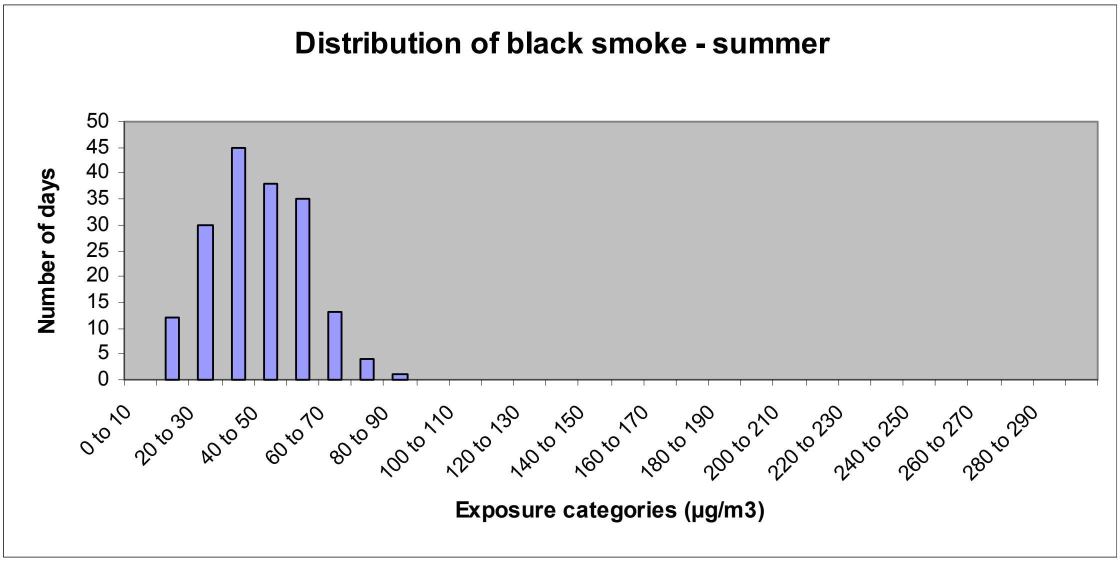


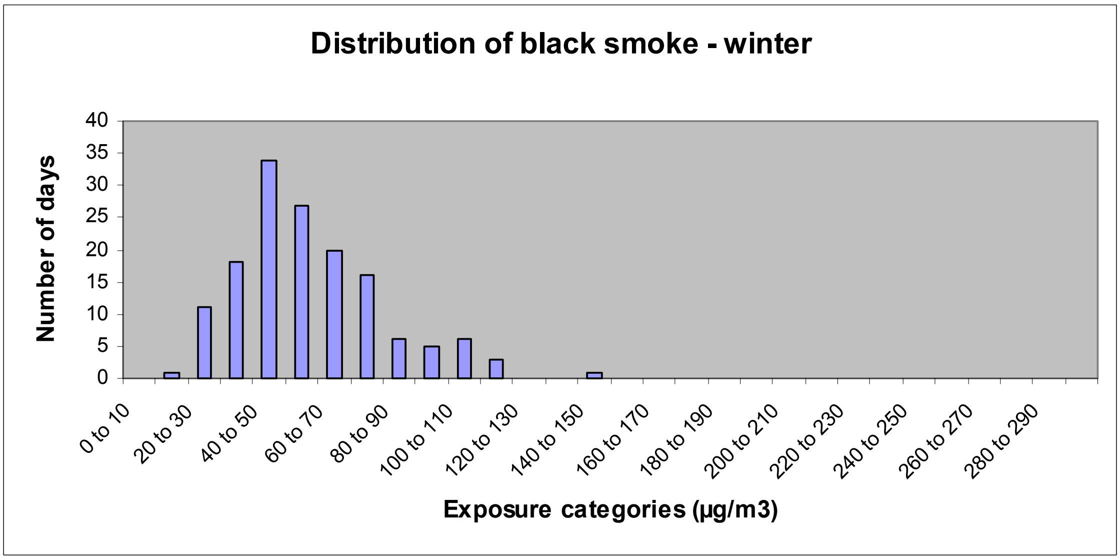

Distribution of PM10 - summer
Number of days
0
10
20
30
40
50
60
70
80
90
100
0 to 10
20 to 30
40 to 50
60 to 70
80 to 90
100 to 110
120 to 130
140 to 150
160 to 170
180 to 190
200 to 210
220 to 230
240 to 250
260 to 270
280 to 290
Exposure categories (µg/m3)


Distribution of PM10 - winter
Number of days
0
10
20
30
40
50
60
70
80
0 to 10
20 to 30
40 to 50
60 to 70
80 to 90
100 to 110
120 to 130
140 to 150
160 to 170
180 to 190
200 to 210
220 to 230
240 to 250
260 to 270
280 to 290
Exposure categories (µg/m3)

The 3 following figures depict distributions of BS during the year, in summer and in winter. The distributions of BS concentrations are larger in winter than in summer.







Recently, Lyon's Plan for Atmospheric Protection (PPA) involves three workshops or groups: 1°) coordination, 2°) emissions and 3°) air quality and impact. The first group is concerned with defining aims, coordination with the "Plan des Déplacements Urbains" (PDU), validation of simulations assessed by the other workshops and communication.
The second group will describe and analyse emissions, be informed on previous measures or projects aimed at reducing air pollution or significantly improving the quality of air. It will also proposes simulations to attain the objectives of the coordination workshop.
The third group will give information to concerned areas, map out the air surveillance stations on those areas, be informed about the evolution of the air quality from the onset of its surveillance and analyse the phenomena of spread and modification of pollutants. This group will use and test the simulations proposed by the second group on public health. Its work will concern more especially the health impact assessment (HIA).

Health data

- The department specialised in mortality data (CepiDC) at the National Health and Medical Research Institute (INSERM) provides medical causes of death based on the international classification of diseases (ICD9). The most recently available data were for the year 1999. A quality control programme of the mortality data was performed. No missing data was found.
- Data on hospital admissions concerned public and private hospitals and were extracted from the Medical Program Information Systems (PMSI) by the hospital information technical agency (ATIH) for the year 2000. A quality control is done for the database with more than 95% completeness. No missing data admission cause has been found.
- Age-standardised total mortality rate (ICD9 = [000-999]) was 663.7 per 100,000 inhabitants, using the European population as a reference[1].

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[1] UNITED NATIONS. Population Division Department of Economic and Social Affairs. World Population Prospects: The 2000 Revision.

Table 3. Daily mean number and annual rate per 100,000 of deaths and hospital admissions

Health outcome	ICD9	ICD10	Daily mean number (SD)	Number of cases per 100,000
Short term HIA				
All causes mortality*	< 800	A00-Q99	15.39 (4.61)	1.97
Cardiovascular mortality	390-459	I00-I99	5.23 (2.41)	0.67
Respiratory mortality	460-519	J00-J99	1.21 (1.26)	0.15
Cardiac mortality	390-429	I00-I52	3.51 (2.07)	0.45
Cardiac hospital admissions	390-429	I00-I52	14.85	1.90
Respiratory hospital admissions	460-519	J00-J99	14.58	1.86
Long term HIA				
Total mortality	0-999	A00-T98	**16.59**	**2.12**
Cardiopulmonary mortality	401-440 460-519	I10-I70 J00-J99	6.02	0.77
Lung cancer mortality	162	C33-C34	0.92	0.12

* For short and long term scenarios

Health impact assessment

Different scenarios were used to evaluate short-term and long-term exposure to particulate pollution. In the city of Lyon, these scenarios were built for three indicators of particulate pollution: BS, PM_{10} and $PM_{2.5}$. The estimated health impacts of these indicators may overlap, and caution is recommended in the interpretation of findings. Under no circumstances should the findings of these indicators be summed-up because they represent the same type of pollution.

Different tools and different estimates were used to evaluate the short- and long-term impacts of this particulate pollution on health. (Table 4).

Table 4. Summary SHORT-TERM Health impact assessment

	Health indicator	ICD		Tool	RR (95% IC) For 10 µg/m^3 increase
Attributable cases		**ICD9**	**ICD10**		
		ST HIA for all cities report			
PM10	All ages, all causes mortality (excluding external causes)	< 800	A00-R99	French PSAS-9 Excel spreadsheet	WHO, 2003: 1.006 (1.004 -
	All ages, cardiovascular mortality	390-459	I00-I99		WHO, 2003: 1.009 (1.005 -
	All ages, respiratory mortality	460-519	J00-J99		WHO, 2003: 1.013 (1.005 -
	All ages, cardiac hospital admissions	390-429	I00-I52		Le Tertre et al. 2002: 1.006 (1.003 -
	All ages, respiratory hospital admissions	460-519	J00-J99		Apheis 3: 1.0114 (1.0062 -
BS	All ages, all causes mortality (excluding external causes)	< 800	A00-R99	French PSAS-9 Excel spreadsheet	WHO, 2003: 1.006 (1.004 -
	All ages, cardiovascular mortality	390-459	I00-I99		WHO, 2003: 1.004 (1.002 -
	All ages, respiratory mortality	460-519	J00-J99		WHO, 2003: 1.006 (0.998 -
	All ages, cardiac hospital admissions	390-429	I00-I52		Le Tertre et al. 2002:1.011 (1.004 - 1.019)
	All ages, respiratory hospital admissions	460-519	J00-J99		Apheis 3: 1.0030 (0.9985 -
PM10 Distributed lag (40 days)	All ages, all causes mortality (excluding external causes)	< 800	A00-R99	French PSAS-9 Excel spreadsheet	Zanobetti et al. 2002: 1.01227 (1.0081 -
	All ages, cardiovascular mortality	390-459	I00-I99		Zanobetti et al. 2003: 1.01969 (1.0139 -
	All ages, respiratory mortality	460-519	J00-J99		Zanobetti et al. 2003: 1.04206 (1.0109 -
		Complementary ST HIA for some cities reports			
PM10 with shrunken stimates	All ages, all causes mortality (excluding external causes)	< 800	A00-R99	French PSAS-9 Excel spreadsheet	Apheis 3: RRs and 95% CI of the shrunken estimate for each city
					RR
				Athens	1,012 (1,008-1,017)
				Barcelona	1,009 (1,005-1,012)
				Budapest	1,005 (0,999-1,011)
				Cracow	1,004 (0,998-1,009)
				London	1,007 (1,004-1,010)
				Madrid	1,006 (1,002-1,010)
				Paris	1,005 (1,001-1,009)
				Rome	1,011(1,006-1,015)
				Stockholm	1,006 (0,999-1,013)
				Tel-Aviv	1,006 (1,002-1,011)

Table 4 (cont), Summary LONG-TERM Health impact assessment (HIA)

	Health indicator	**ICD 9**	**ICD10**	**Tool**	**RR (95% IC) For 10 µg/m^{3} increase**	**Scenarios**
			Long term HIA for all-cities report			
Attributable cases						**Annual mean**
PM10	All causes mortality (excluding external causes)	< 800	A00-R99	French PSAS-9 Excel spreadsheet	Kunzli et al, 2000 1.043 (1.026 -1.061)	Reduction to 40 µg/m^{3} Reduction to 20 µg/m^{3} Reduction by 5 µg/m^{3}
PM2.5	All causes mortality Cardiopulmonary mortality LCA	0-999 401-440 and 460-519 162	A00-Y98 I10-I70 and J00-J99 C33-C34	French PSAS-9 Excel spreadsheet	CA III Pope, 2002 1.06 (1.02 - 1.11) 1.09 (1.03 - 1.16) 1.14 (1.04 - 1.23)	Reduction to 20 µg/m^{3} Reduction to 15 µg/m^{3} Reduction by 3.5 µg/m^{3}
YoLL						**Annual mean**
PM2.5	All causes mortality Cardiopulmonary mortality LCA	0-999 401-440 and 460-519 162	A00-Y98 I10-I70 and J00-J99 C33-C34	WHO AirQ software	CA III Pope, 2002 1.06 (1.02 - 1.11) 1.09 (1.03 - 1.16) 1.14 (1.04 - 1.23)	Reduction to 20 µg/m^{3} Reduction to 15 µg/m^{3} Reduction by 3.5 µg/m^{3}
			Complementary LT HIA for some cities report			
Prospective scenarios on air pollution, prospective scenarios on birth numbers	Local choice	–	–	WHO AirQ software	–	–

Different approaches were also used to describe the impacts:
For BS, short-term findings are expressed in terms of number of attributed deaths per year
For PM_{10}, short and long-term findings are expressed in terms of number of attributed deaths per year.
For $PM_{2.5}$, long-term findings are expressed in terms of number of attributed deaths per year and number of expected years of life lost due to the deaths in one year.

Short-term scenarios

The following scenarios were used to estimate the acute effects of short-term exposure to BS/ PM_{10} on mortality and hospital admissions over one year:

Short term HIA scenarios for BS

Three scenarios were used to estimate the acute health effects of BS on all causes (excluding external causes), cardiovascular and respiratory mortality over one year:

- reduction of BS levels to a 24-hour value of 50 µg/m^3 on all days exceeding this value
- reduction of BS levels to a 24-hour value of 20 µg/m^3 on all days exceeding this value
- reduction by 5 µg/m^3 of all the 24-hour values of BS.

Short term HIA scenarios for PM_{10}

- **Short-term HIA of PM_{10} on 0-1 days and cumulative HIA of PM_{10} up to 40 days**

Three scenarios were used to estimate the acute health effects of PM_{10} on 0-1 days and cumulative health effects of PM_{10} up to 40 days on all causes (excluding external causes), cardiovascular and respiratory mortality over one year:

- reduction of PM_{10} levels to a 24-hour value of 50 µg/m^3 on all days exceeding this value (2005 and 2010 limit values for PM_{10})
- reduction of PM_{10} levels to a 24-hour value of 20 µg/m^3 on all days exceeding this value (to allow for cities with low levels of PM_{10})
- reduction by 5 µg/m^3 of all the 24-hour values (to allow for cities with low levels of PM_{10})

- **Combined local and meta-analytic estimates for short-term HIA of PM_{10}**

The same scenarios as above were used and combined local and meta-analytic estimates to calculate the acute health effects of PM_{10} on all causes of death (excluding external causes) over one year. This sensitivity analysis was done to study the interest of including the weight of local estimates in the combined (meta-analytic) one.

Long-term scenarios

Long-term HIA scenarios for PM_{10}

Three scenarios were used to estimate the chronic effects of long-term exposure to PM_{10} on all causes of mortality (excluding external causes) over one year:

- reduction of the annual mean value of PM_{10} to a level of 40 µg/m^3 (2005 limit values)
- reduction of the annual mean value of PM_{10} to a level of 20 µg/m^3 (2010 limit values)
- reduction by 5 µg/m^3 in the annual mean value of PM_{10} (to allow for cities with low levels)

Long term HIA for $PM_{2.5}$

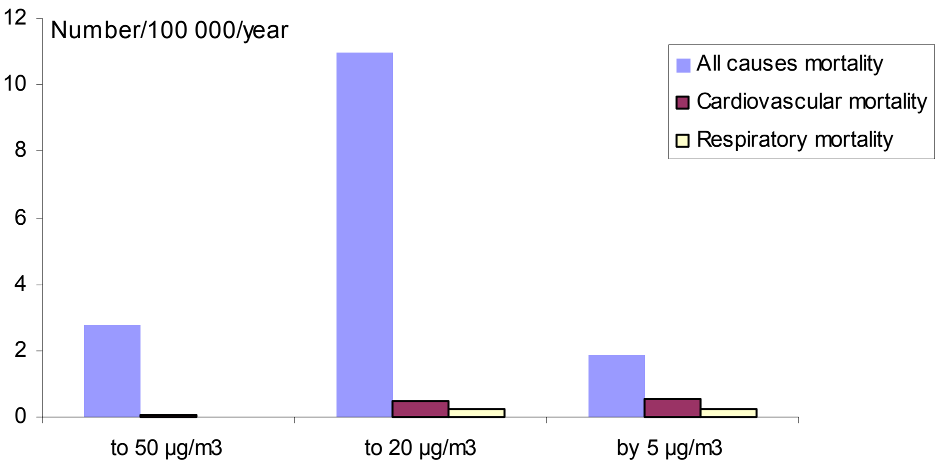
We estimated chronic effects of $PM_{2.5}$ as impacts on mortality due to all causes, to cardiopulmonary and to lung cancer deaths in people over 30 years old in Lyon.

The following three pollution scenarios were considered:

- reduction of the annual mean value of $PM_{2.5}$ to a level of 20 µg/m^3 [2]
- reduction of the annual mean value of $PM_{2.5}$ to a level of 15 µg/m^3 [2]
- reduction by 3.5 µg/m^3 in the annual mean value of $PM_{2.5}$ (to allow for cities with low levels of $PM_{2.5}$)

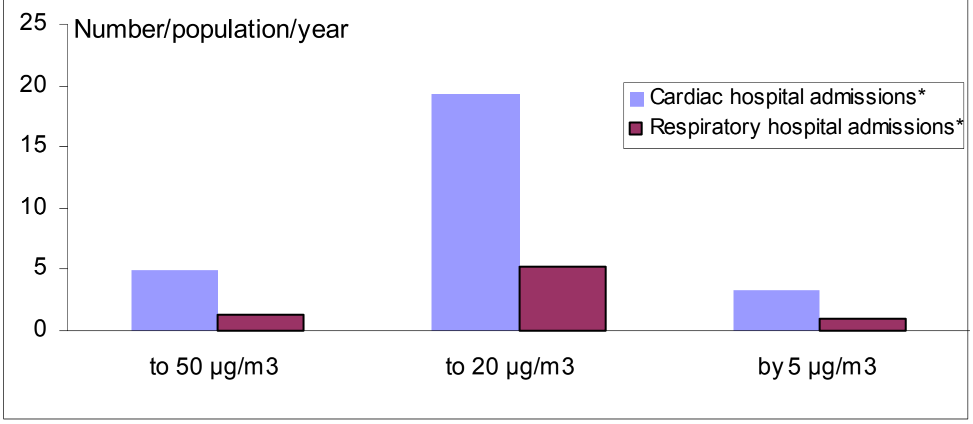
BS findings

Figure 2. Black smoke : reductions to 50-20-by 5 µg/m^3. Short-term health impact on total* and specific mortality *



* All causes mortality excluding external causes (ICD9 < 800), cardiovascular mortality (ICD9 390-459), respiratory mortality (ICD9 460-519).
** Black smoke data for 2001, mortality data for 1999

Figure 3. Black smoke : reductions to 50-20-by 5 µg/m3.
Short-term health impact on hospital admissions



* Cardiac (ICD9 390-429) and respiratory hospital admissions (ICD9 460-519)
** Black smoke data for 2001, mortality data for 1999

The greatest impact on expected mortality and hospital admissions is observed in the case of a daily reduction of BS levels from above 20 to 20 µg.m^{-3}. Mainly, the best impact as shown in tables 1 and 4 for BS findings (see appendix) would be obtained for deaths from all causes (86 lives gained) and hospital admissions for cardiac diseases (151 admissions avoided).

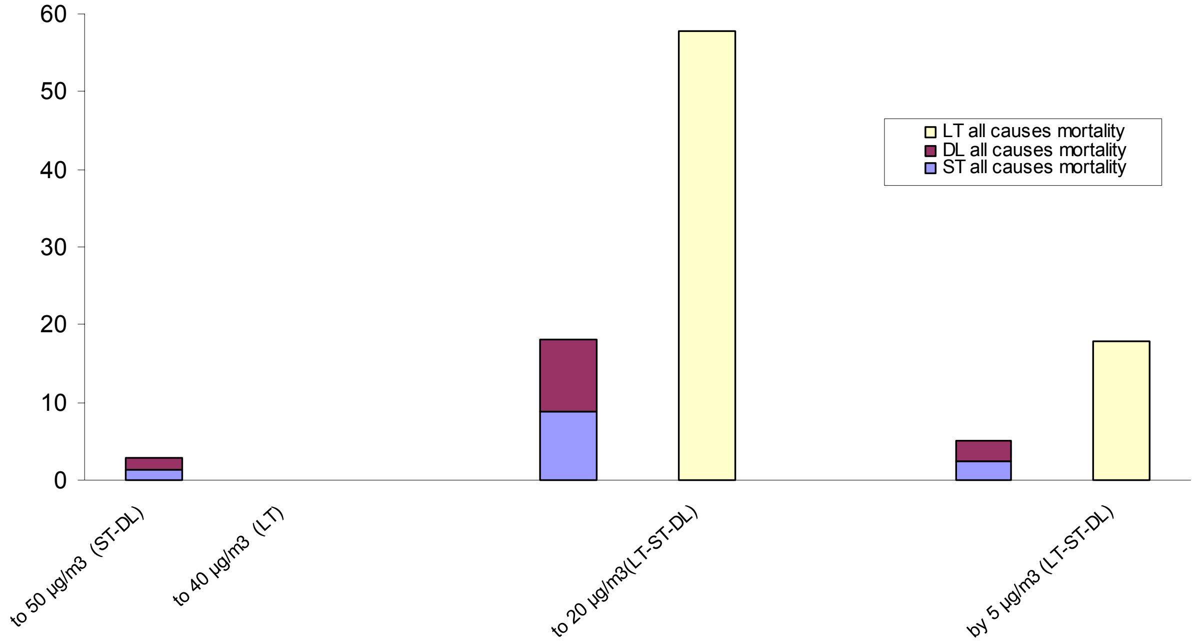
PM_{10} findings

1. Short-term HIA of PM_{10} on 0-1 days and cumulative HIA of PM_{10} up to 40 days, and long term HIA of PM_{10}

1.1. Mortality findings

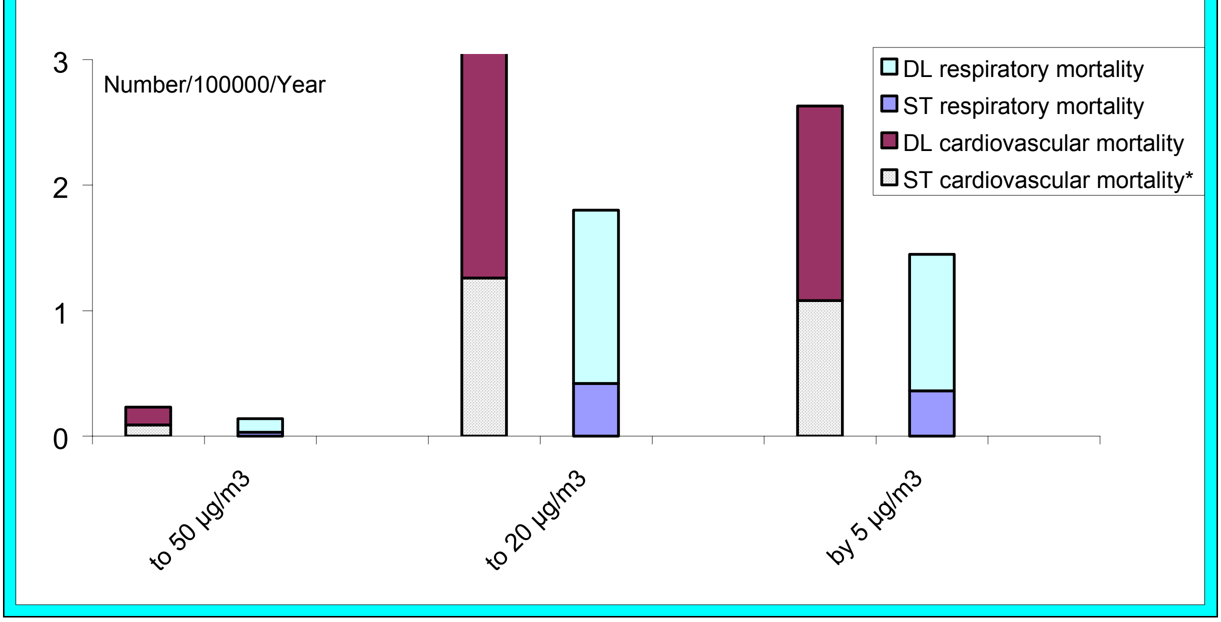
The following graphs show the health impact of PM_{10} on mortality for different lags: short-term-ST (0-1 day lag), cumulative effect –DL-distributed lag (up to 40 days lag) and long-term LT (years).

Figure 4. PM10: reductions to 50/40-20-by 5 µg/m³. Short term (ST), cumulative (DL), long term (LT) health impact on all causes mortality (ICD 9 <800)



* PM_{10} data for 2000, mortality data for 2000

Figure 5. PM10: reductions to 50-20-by 5 µg/m3. Short term (ST), cumulative (DL) health impact on specific mortality



*Cardiovascular mortality (ICD9 390-459), respiratory mortality (ICD9 460-519).
** PM10 data for 2000, mortality data for 2000

If PM_{10} levels exceeding 20 µg.m^{-3} for all days were reduced to 20 µg.m^{-3}, Lyon would expect a decrease of 19 deaths in a year (see figure 4 and table 1 for PM_{10} findings of the appendix). The simulation with 40 days exposure leads to an expected mortality of 40 deaths (see figure

4 and table 5 depicting the cumulative effects of PM_{10} up to 40 days). Similar numbers in a year and 40 days exposure are expected for the mortality in two groups of pathologies (see figure 5): respectively 10 and 15 deaths for cardiovascular diseases (tables 2 and 6 for PM_{10} findings of the appendix) and respectively 3 and 11 deaths for respiratory diseases (tables 3 and 7 for PM_{10} findings of the appendix). Potential benefits of reducing daily PM_{10} levels every day by 5 $\mu g.m^{-3}$ are close to those with a 20 $\mu g.m^{-3}$ reduction. Health impact is bigger when the considered duration of exposure is longer and effects are cumulative over time.

1.2. Hospital admissions findings

We estimated the acute effects of short-term exposure to PM_{10} on cardiac and respiratory hospital admissions over one year.

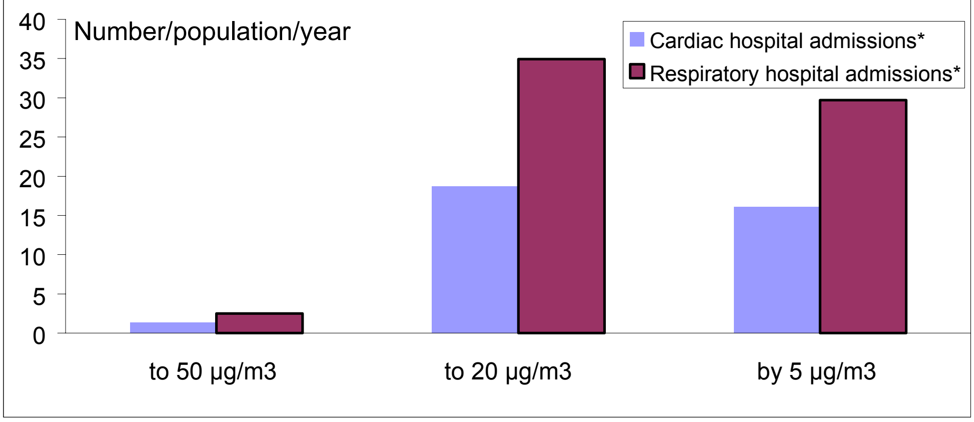


Figure 6. PM_{10} : reductions to 50-20-by 5 µg/m^3.
Short-term health impact on hospital admissions

* Cardiac (ICD9 390-429) and respiratory hospital admissions (ICD9 460-519)
** PM10 data for 2000, mortality data for 2000

The best decrease in hospital admissions of cardiac pathologies is obtained by reducing daily PM_{10} levels from above 20 to 20 $\mu g.m^{-3}$ and every day by 5 $\mu g.m^{-3}$ (see also table 4 for PM_{10} findings of the appendix).

2. Combined local and meta-analytic estimates for the health effects of PM_{10}

Local and meta-analytic estimates (shrunken estimates-SE) were combined to calculate the acute health effects of PM_{10} on all causes of death (excluding external causes) over one year. Lyon did not perform this analysis (figure 7 not available).

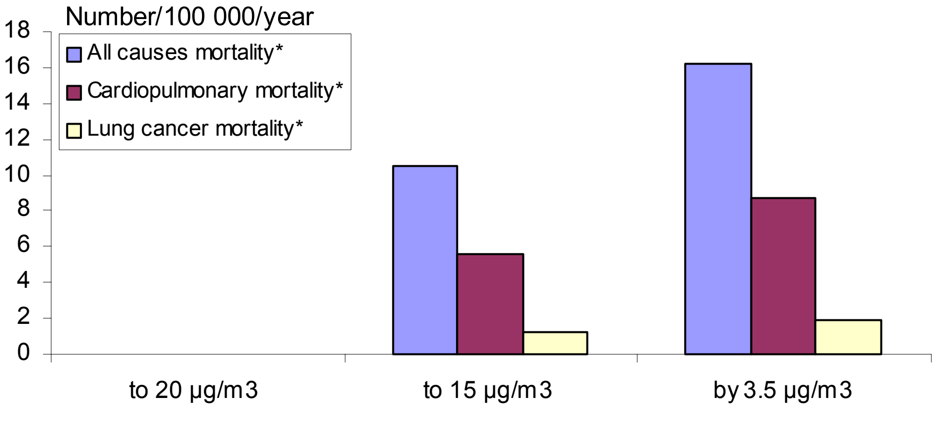
PM2.5 findings

1. Number of attributed cases

Three scenarios were also used to estimate the chronic effects of long-term exposure to $PM_{2.5}$ on mortality over one year.

The following graph presents the attributable number of all causes, cardiopulmonary and lung cancer deaths expressed as per 100,000 inhabitants.

Figure 8. PM$_{2.5}$: reductions to 20-15-by 3.5 µg/m^3. Long-term health impact on total and specific mortality



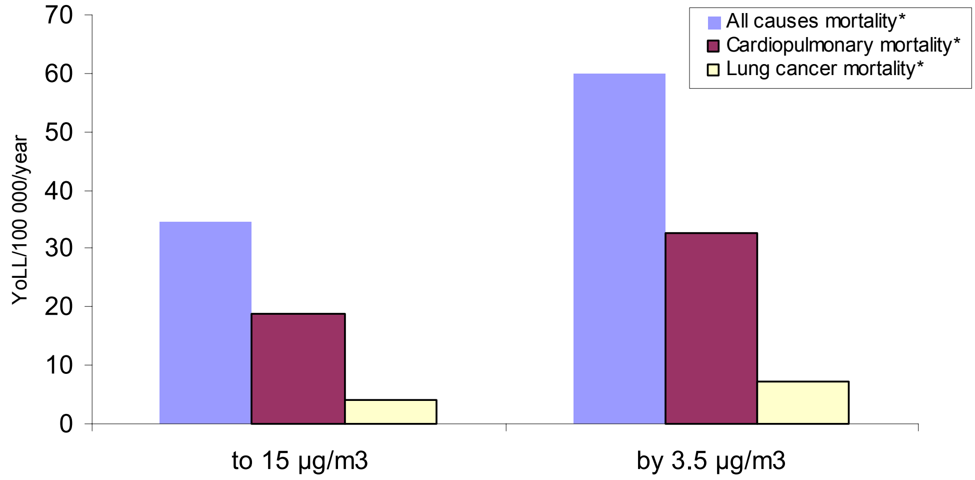
* All causes mortality (ICD9 0-999), cardiopulmonary mortality (ICD9 401-440 and 460-519), lung cancer mortality (ICD9 162).
** PM2.5 data for 2000, mortality data for 2000

Reducing the annual mean of PM$_{2.5}$ by 3.5 µg.m^{-3} leads to the best gain in deaths from all causes and cardiopulmonary deaths (126 lives and 68 gained respectively, see tables 1 and 2 in PM$_{2.5}$ findings in appendix). For a similar scenario, almost 2 lung cancer deaths per 100,000 are avoided (see table 3 in PM$_{2.5}$ findings in appendix). The lung cancer crude mortality rate in France for men and women are respectively 79.4 and 14.9 per 100,000 per year and estimated to 42.9 per 100,000 per year for Lyon.

2. Years of life lost

We estimated the years of life lost attributable to the chronic effects of PM$_{2.5}$ using the data for the year 2000. Figure 9 presents the years of life lost for all causes, cardiopulmonary and lung cancer deaths in people 30 years of age or older in the population of Lyon.

Figure 9. $PM_{2.5}$: reductions to 20-15-by 3.5 µg/m^3. Expected years of life lost for the first year of simulation for total and specific mortality for >30 years old



* All causes mortality (ICD9 0-999), cardiopulmonary mortality (ICD9 401-440 and 460-519), lung cancer mortality (ICD9 162).
** PM2.5 data for 2000, mortality data for 2000

For all causes of deaths, all other things being equal, reduction of $PM_{2.5}$ by 3.5 µg/m^3 in 2003 would save almost 60 years of expected life in people older than 30 years in the city of Lyon. For cardiopulmonary mortality, this number would be around 30 and for lung cancer mortality, more or less 7 (see figure 9 and tables 1 to 3 for $PM_{2.5}$ findings in appendix).

The following table depicts the findings in terms of life expectancy.

Table 5. Life expectancy and its possible increase by reduction of air pollution to 15 ug/m3 in Lyon

		Expected gain in life expectancy (years)		
Age (years)	**Life expectancy (years)**	**Mean**	**Low estimate**	**High estimate**
At birth	80.67	0.13	0.03	0.22
30	51.45	0.13	0.03	0.22
65	20.25	0.10	0.03	0.17

In terms of life expectancy, all other things being equal, if annual mean $PM_{2.5}$ levels (17 µg/m^3) could be reduced to 13.5 µg/m^3, the 51.5 years of life expectancy in a person of 30 years old in the city of Lyon would be increased by 0.13 years, due to reduced risk of death from all causes.

Interpretation of findings

Methods of measuring PM_{10} use TEOM technique. Consequently, a conversion factor of 1.221 to compensate losses of volatile PM_{10} was used in winter. The concentrations of air pollutants have been steady levels since 1993, excepted for SO_2 which decreased consistently and NO_2 showing a slight reduction since 1997.

Age-standardised total mortality rate (ICD9 = [000-999]) was 663.7 per 100,000 inhabitants, rather low compared to the other APHEIS cities which have rates comprised between 579 and 1220. For short term HIA, the mortality from cardiovascular, cardiac and respiratory disease represent 34.0%, 22.8% and 7.9% of the total mortality, respectively. Cardiac and respiratory hospital admissions had a similar daily mean. For long term HIA, the mortality from cardiopulmonary and lung cancer disease accounted for 36.3% and 5.5% of the total mortality respectively.

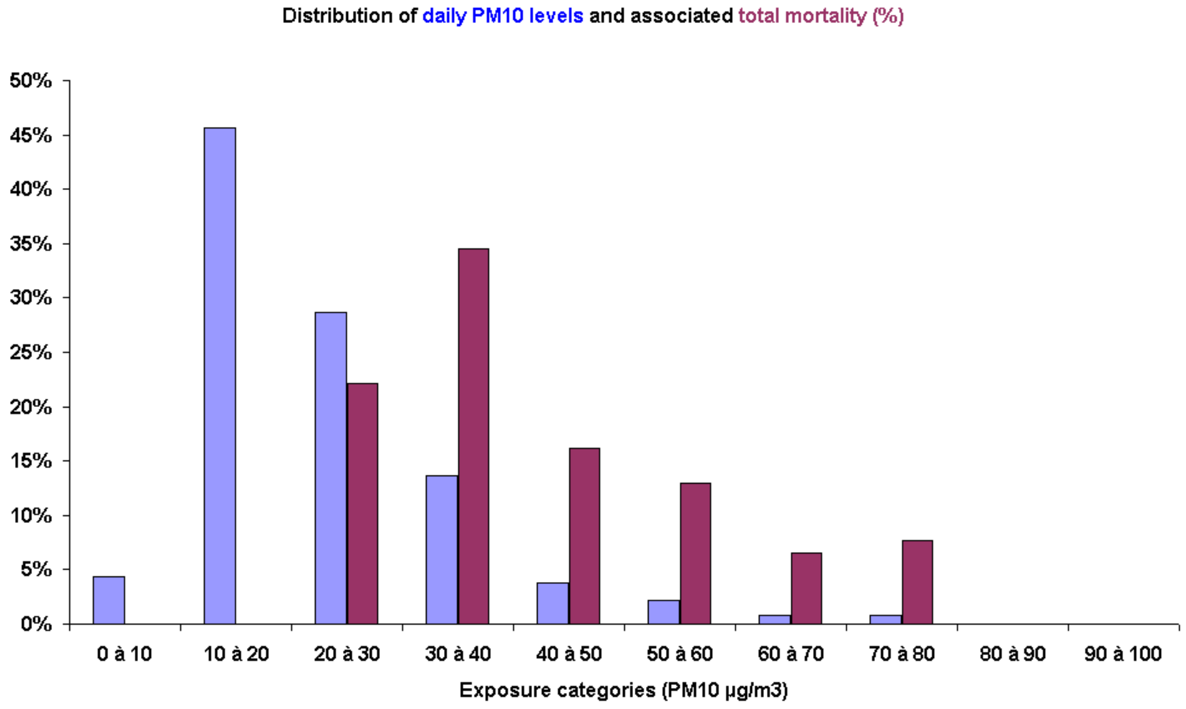
In short term HIA, daily reduction of air pollutant levels from above 20 to 20 µg.m^{-3} represents the best scenario for PM (PM_{10} and $PM_{2.5}$) and BS. The 2010 limit seems more effective to obtain a maximal impact on mortality by reducing air pollution.

For long term HIA, a reduction by 5 or 3.5 µg.m^{-3} in the annual mean value of respectively PM_{10} or $PM_{2.5}$ leads to the best reduction of mortality.

A reduction by 3.5 µg.m^{-3} would be the most efficient strategy: 60 lives would be saved and life expectancy would be increased by 0.13 years among people older than 30 years.

Furthermore, the daily improvement of air quality seems to be more efficient, in terms of health impact than solely on management of air pollution peaks. The following figure confirms the observation that no mortality is associated with PM_{10} levels below 20 µg.m^{-3}. PM_{10} levels between 20 and 40 µg.m^{-3} cause more than 50% of the total mortality.

Short term distribution of PM10 levels and associated percentage of cases



General comments

Before the air quality law in 1996 and the elaboration of the Regional Plan for the Quality of Air in the city of Lyon (Plan Régional pour la Qualité de l'air: PRQA), the Rhône-Alpes region's Prefecture created a structure in 1990 called "Permanent Secretariat for the Prevention of Industrial Pollution and Risk in the Lyon Agglomeration" (Secrétariat pour la Prévention de la Pollution Industrielle et des Risques dans l'Agglomération Lyonnaise: SPIRAL). It aims at reducing the pollutants and industrial risk by defining priority actions.

More recently created is the Lyon's Plan for Atmospheric Protection (PPA) that will complete the regional planification. It has set up three workshops or groups: 1°) coordination, 2°) emissions and 3°) air quality and impact. The third group task will focus mainly on the health impact assessment.

A real awareness of the air pollution problem is obvious. Nevertheless, it is not followed by concrete public health decisions except for the alert procedure triggered by the Prefecture, the elaboration of the PDU and the annual "day without cars". The information obtained from the PRQA has incited decision makers be more aware of the air pollution problems and therefore expect more health studies. Although the PRQA created a permanent health assessment committee on air pollution impact, information does not spread at the decision maker level. Moreover, the general public remains superficially, punctually or not adequately informed or sensitised.

The current results of this health impact assessment could be a useful tool in policy decision making for the different actors involved in the management of air pollution.

Conclusions

The city of Lyon is still not completely at the "APHEIS hour" although several great initiatives have been taken such as the creation of the "Permanent Secretariat for the Prevention of Industrial Pollution and Risk in the Lyon Agglomeration", the elaboration of the Regional Plan for the Quality of Air and the beginning of the Lyon's Plan for Atmospheric Protection.

A communication tool developed by APHEIS would be useful for Lyon city which is one of the big European towns. This tool could be used in the workshop communication of the Lyon's Plan for Atmospheric Protection.

Until this day, HIA has been developed for two pollutants: PM and BS. Ozone should be included in the HIA because its health effects are sufficiently well known and it is a major pollutant during summer, particularly during heat waves which are expected to be more and more frequent. New pollutants such as benzene for long term HIA and NO_2, which is related to the consistently increasing traffic would be useful to study.

If the quality of air surveillance is now strongly implemented and a real awareness of the air pollution problem is obvious, health measures are currently limited to some measures taken to reduce pollution peak. As decision makers expect more results of health studies, the current results of this health impact assessment could be a useful tool in policy decision making for the different actors involved in the management of air pollution. But how to introduce the results in the decision making circuit and present these results in a pedagogic, understandable and suitable ways is yet to be resolved. The answers to these two major questions seem to be the big challenge to reach by PSAS-9 and APHEIS programs in Lyon city.

Appendix

1. **Add the questionnaires for your city on the exposure measurement methods and health data**

Harmonised compilation of information indicating the exposure relevant area of the city, number of PM10, PM2.5 or BS monitoring sites, and the type, sampling and measurement characteristics of stations selected for the HIA of APHEIS

1. City: LYON___________

2. Total area of agglomeration (km²): ~500 km2________

3. Area (km²) covered by the air monitoring network in the city: 132 km2_________

4. Number of population in this (exposure relevant) area: 782 828_________

5. Total number of PM10 monitoring stations in this area: 5_(2000)________

6. Total number of BS monitoring stations in this area: 1_(2001)________

7a. Total number of TSP monitoring stations in this area: 1______________

7b. Total number of PM2.5 monitoring stations in this area: 2_(2001)________

8. Number of selected PM10 monitoring stations for HIA: 2______________

9. Number of selected BS monitoring stations for HIA: 1______________

10a. Number of selected TSP monitoring stations for HIA: 0______________

10b. Number of selected PM2.5 monitoring stations for HIA: 0______________

11. Measurement interval (please cross)

continuous ☒ hourly ☐ 24 hours ☐ weekly ☐ 2 weekly ☐

12. Quality assurance and control (please cross)

yes ☒ no ☐ do not know ☐

13. Data quality (please cross)

validated data ☒ invalidated data ☐

14. Name, classification and sampling characteristics of the monitoring site (traffic, kerbside, building line, commercial, urban residential, sub-urban, rural, industrial, others)

Name	PM10/BS/PM2.5	Classification
(for example: Bismarckplatz	PM10	residential
	Croix Luizet / TEOM	urban residential
	Bossuet/ TEOM	urban residential
	BS	
	Puits Gaillot	

15. Measurement method / Type of instrument

BS: _Filtromat________________________________

PM10 manual:____
automated:___TEOM______________________________
probe temperature (in °C):_ambient temperature__
optical:____

PM2.5 manual:____
automated:_____________________________________
probe temperature (in °C):__________________
optical:____

16. Using PM10 data for your city HIA calculation, did you used a conversion factor in order to compensate losses of volatile particulate matter?

no ☐

yes ☒ if yes, a) which factor: ____1.221 in winter ____________

b) is it a default factor? yes ☒ no ☐

or c) derived from own parallel measurements (reference method vs. TEOM or beta attenuation) yes ☒ no ☐

17. If your PM2.5 data have been calculated from your PM10 data, what conversion

factor did you use? factor:_______**0.7**______________________

2. Tables for black smoke findings

Tables 1, 2, 3 present the attributable number of all causes, cardiovascular and respiratory deaths expressed as absolute numbers and as rates per 100,000 inhabitants. Table 4 presents the results for cardiac and respiratory hospital admissions.

Table 1. Deaths all causes (ICD-9: < 800 for year 1999). Potential benefits of reducing daily BS levels (2001) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of BS.

		Attributable cases per year					
	Number of days per year exceeding 20 and 50 µg.m^{-3}	N° of deaths			N° of deaths per 100,000		
Scenarios		**central**	**lower**	**upper**	**central**	**lower**	**upper**
20 µg.m^{-3}	308	86.0	57.1	130	11.0	7.30	16.6
50 µg.m^{-3}	122	21.7	14.4	32.7	2.77	1.84	4.17
By 5 µg.m^{-3}	NA*	14.6	9.77	22.0	1.87	1.25	2.80

**NA: not applicable*

Table 2. Cardiovascular deaths (ICD-9: 390-459 for year 1999). Potential benefits of reducing daily BS levels (2001) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effect of BS.

		Attributable cases per year					
	Number of days per year exceeding 20 and 50 µg.m^{-3}	N° of deaths			N° of deaths per 100,000		
Scenarios		**central**	**lower**	**upper**	**central**	**lower**	**upper**
20 µg.m^{-3}	308	19.5	9.73	34.4	2.49	1.24	4.39
50 µg.m^{-3}	122	4.90	2.45	8.61	0.63	0.31	1.10
By 5 µg.m^{-3}	NA*	3.35	1.68	5.86	0.43	0.21	0.75

Table 3. Respiratory deaths (ICD-9: 460-519 and year 1999). Potential benefits of reducing daily BS levels (2001) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of BS.

		Attributable cases per year					
		N° of deaths			**N° of deaths per 100,000**		
Scenarios	**Number of days per year exceeding 20 and 50 µg.m^{-3}**	**central**	**lower**	**upper**	**central**	**lower**	**upper**
20 µg.m^{-3}	308	6.76	<0	17.2	0.86	<0	2.19
50 µg.m^{-3}	122	1.71	<0	4.31	0.22	<0	0.55
By 5 µg.m^{-3}	NA*	1.15	<0	2.87	0.15	<0	0.37

Table 4. Cardiac (ICD-9: 390-429) and respiratory (ICD9: 460-519) hospital admissions (year 2000). Potential benefits of reducing daily BS levels (2001) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number (95% confidence limits) attributable to the acute effects of BS.

		Attributable cases per year		
		N° of deaths		
Scenarios	**Number of days per year exceeding 20 and 50 µg.m^{-3}**	**central**	**lower**	**upper**
Hospital admissions for cardiac diseases (all ages)				
20 µg.m^{-3}	308	151	54.4	265
50 µg.m^{-3}	122	38.7	13.9	67.5
By 5 µg.m^{-3}	NA*	25.3	9.23	43.7
Hospital admissions for respiratory diseases (all ages)				
20 µg.m^{-3}	308	40.9	<0	103
50 µg.m^{-3}	122	10.2	<0	25.7
By 5 µg.m^{-3}	NA*	7.03	<0	17.6

**NA: not applicable*

3. Tables for PM_{10} findings

3.1. Health effects of PM_{10} on 0-1 days

Tables 1, 2, 3 present the attributable number of all causes, cardiovascular and respiratory deaths expressed as absolute numbers and as rates per 100,000 inhabitants. Table 4 presents the results for cardiac and respiratory hospital admissions.

Table 1. Deaths from all causes (ICD-9 < 800 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and on all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
		N° of deaths			N° of deaths per 100,000		
Scenarios	Number of days per year exceeding 20 and 50 µg.m^{-3}	central	lower	upper	central	lower	upper
20 µg.m^{-3}	175	19.4	12.9	25.9	2.47	1.65	3.30
50 µg.m^{-3}	14	1.37	0.91	1.83	0.18	0.12	0.23
By 5 µg.m^{-3}	NA*	16.7	11.1	22.2	2.13	1.42	2.84

Table 2. Cardiovascular deaths (ICD-9: 390-459 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and on all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
		N° of deaths			N° of deaths per 100,000		
Scenarios	Number of days per year exceeding 20 and 50 µg.m^{-3}	central	lower	upper	central	lower	upper
20 µg.m^{-3}	175	9.88	5.48	14.31	1.26	0.70	1.83
50 µg.m^{-3}	14	0.71	0.39	1.02	0.09	0.05	0.13
By 5 µg.m^{-3}	NA*	8.46	4.70	12.20	1.08	0.60	1.56

Table 3. Respiratory deaths (ICD-9: 460-519 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 $\mu g.m^{-3}$, above 50 to 50 $\mu g.m^{-3}$ and on all days by 5 $\mu g.m^{-3}$. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
		N° of deaths			N° of deaths per 100,000		
Scenarios	Number of days per year exceeding 20 and 50 $\mu g.m^{-3}$	central	lower	upper	central	lower	upper
20 $\mu g.m^{-3}$	175	3.31	1.27	5.37	0.42	0.16	0.69
50 $\mu g.m^{-3}$	14	0.24	0.09	0.39	0.03	0.01	0.05
By 5 $\mu g.m^{-3}$	NA*	2.80	1.08	4.52	0.36	0.14	0.58

Table 4. Cardiac (ICD9: 390-429) and respiratory (ICD9: 460-519) hospital admissions (year 2000). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 $\mu g.m^{-3}$, above 50 to 50 $\mu g.m^{-3}$ and all days by 5 $\mu g.m^{-3}$. Absolute number (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year		
		N° of admissions		
Scenarios	Number of days per year exceeding 20 and 50 $\mu g.m^{-3}$	central	lower	upper
Hospital admissions for cardiac diseases (all ages)				
20 $\mu g.m^{-3}$	175	18.7	9.33	28.1
50 $\mu g.m^{-3}$	14	1.33	0.66	1.99
By 5 $\mu g.m^{-3}$	NA*	16.1	8.06	24.2
Hospital admissions for respiratory diseases (all ages)				
20 $\mu g.m^{-3}$	175	34.9	18.9	51.3
50 $\mu g.m^{-3}$	14	2.51	1.36	3.69
By 5 $\mu g.m^{-3}$	NA*	29.7	16.2	43.5

**NA: not applicable*

3.2. Cumulative health effects of PM_{10} up to 40 days

Tables 5, 6, 7 present the attributable number of all causes, cardiovascular and respiratory deaths expressed as absolute numbers and as rates per 100,000 inhabitants.

Table 5. Cumulative health effects of PM_{10} up to 40 days and all causes of deaths (ICD-9: < 800 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and on all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
		N° of deaths			N° of deaths per 100,000		
Scenarios	Number of days per year exceeding 20 and 50 µg.m^{-3}	central	lower	upper	central	lower	upper
20 µg.m^{-3}	175	39.7	26.1	53.2	5.07	3.34	6.79
50 µg.m^{-3}	14	2.86	1.89	3.83	0.37	0.24	0.49
By 5 µg.m^{-3}	NA*	33.7	22.3	45.0	4.30	2.84	5.75

**NA: not applicable*

Table 6. Cumulative health effects of PM_{10} up to 40 days and cardiac deaths (ICD-9: 390-429 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
		N° of deaths			N° of deaths per 100,000		
Scenarios	Number of days per year exceeding 20 and 50 µg.m^{-3}	central	lower	upper	central	lower	upper
20 µg.m^{-3}	175	14.6	10.2	18.9	1.86	1.31	2.42
50 µg.m^{-3}	14	1.07	0.75	1.39	0.14	0.10	0.18
By 5 µg.m^{-3}	NA*	12.1	8.58	15.7	1.55	1.10	2.01

Table 7. Cumulative health effects of PM_{10} up to 40 days and respiratory deaths (ICD-9: 460-519 and year 1999). Potential benefits of reducing daily PM_{10} levels (2000) above 20 to 20 µg.m^{-3}, above 50 to 50 µg.m^{-3} and all days by 5 µg.m^{-3}. Absolute number and number per 100,000 inhabitants (95% confidence limits) attributable to the acute effects of PM_{10}.

		Attributable cases per year					
	Number of days per year exceeding 20 and 50 µg.m^{-3}	N° of deaths			N° of deaths per 100,000		
Scenarios		**central**	**lower**	**upper**	**central**	**lower**	**upper**
20 µg.m^{-3}	175	10.8	2.75	19.4	1.38	0.35	2.48
50 µg.m^{-3}	14	0.84	0.22	1.50	0.11	0.03	0.19
By 5 µg.m^{-3}	NA*	8.56	2.23	15.0	1.09	0.03	1.91

3.3. Combined local and meta-analytic estimates for the health effects of PM_{10}

Table 8 is not available for Lyon.

3.4. Long term HIA for PM_{10}

Table 9 presents the attributable number of all causes of deaths expressed as absolute numbers and as rates per 100,000 inhabitants.

Table 9. Deaths all causes (ICD9: < 800 and year 1999). Potential benefits of reducing annual mean values of PM_{10} (2000) to levels of 20 and 40 µg/m^3, and by 5 µg/m^3. Absolute number of deaths and number of deaths per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of PM_{10}.

		Attributable cases per year					
Scenarios	**Number of days per year exceeding 20 and 40 µg.m^{-3}**	N° of deaths			N° of deaths per 100,000		
		central	**lower**	**upper**	**central**	**lower**	**upper**
20 µg.m^{-3}	175	110	66.5	155	14.0	8.50	19.8
By 5 µg.m^{-3}	NA*	117	71.2	166	15.0	9.10	21.1

**NA: not applicable*

4. Tables for $PM_{2.5}$ findings

4.1. LT $PM_{2.5}$: Attributable Cases

Tables 1, 2, 3 present the attributable number of all causes, cardiopulmonary and lung cancer deaths expressed as absolute numbers and as rates per 100,000 inhabitants.

Table 1. Deaths all causes (ICD-9: 0-999 and year 1999). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 and 20 µg/m^3, and by 3,5 µg/m^3. Absolute number of deaths and number of deaths per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

		Attributable cases per year					
Scenarios	Number of days per year exceeding 15 and 20 µg.m^{-3}	N° of deaths			N° of deaths per 100,000		
		central	lower	upper	central	lower	upper
15 µg.m^{-3}	163	82.2	21.4	144	10.5	2.74	18.4
By 3.5 µg.m^{-3}	NA*	126	32.9	222	16.2	4.20	28.3

**NA: not applicable*

Table 2. Cardiopulmonary deaths (ICD-9: 401-440 and 460-519 and year 1999). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 and 20 µg/m^3, and by 3,5 µg/m^3. Absolute number of deaths and number of deaths per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

		Attributable cases per year					
Scenarios	Number of days per year exceeding 15 and 20 µg.m^{-3}	N° of deaths			N° of deaths per 100,000		
		central	lower	upper	central	lower	upper
15 µg.m^{-3}	163	44.2	15.9	72.9	5.64	2.03	9.31
By 3.5 µg.m^{-3}	NA*	67.9	24.3	112	8.67	3.11	14.4

**NA: not applicable*

Table 3. Lung cancer deaths (ICD-9: 162 and year 1999). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 and 20 µg/m^3, and by 3,5 µg/m^3. Absolute number of deaths and number of deaths per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

		Attributable cases per year					
Scenarios	**Number of days per year exceeding 15 and 20 µg.m^{-3}**	**N° of deaths**			**N° of deaths per 100,000**		
		central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg.m^{-3}	163	9.56	3.23	16.0	1.22	0.41	2.05
By 3,5 µg.m^{-3}	NA*	14.7	4.93	24.7	1.87	0.63	3.15

**NA: not applicable*

4.2. LT PM2.5: Years of Life Lost

Tables 1, 2, 3 present the years of life lost respectively for all causes, cardiopulmonary and lung cancer deaths expressed as absolute numbers and as rates per 100,000 inhabitants.

Table 1. Deaths all causes >30 years, male and female, for one year (ICD-9: 0-999 and year 2003). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 µg/m^3 and by 3,5 µg/m^3. Years of life lost (YoLL) and YoLL per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

	Years of life lost					
	YoLL			**YoLL per 100,000**		
	central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg/m^3	34.4	9.07	59.5	4.38	1.15	7.58
By 3,5 µg/m^3	60.0	15.9	103	7.63	2.02	13.2

Table 2. Cardiopulmonary deaths >30 years, male and female, for one year (ICD-9: 401-440 and 460-519 and year 2003). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 and by 3,5 µg/m^3. Years of life lost (YoLL) and YoLL per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

	Years of life lost					
	YoLL			**YoLL per 100,000**		
	central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg/m^3	18.7	6.81	30.5	2.38	0.87	3.88
By 3,5 µg/m^3	32.5	11.9	52.7	4.14	1.51	6.71

Table 3. Lung cancer deaths >30 years, male and female, for one year (ICD-9: 162 and year 2003). Potential benefits of reducing annual mean values of $PM_{2,5}$ (2000) to levels of 15 and by 3,5 µg/m^3. Years of life lost (YoLL) and YoLL per 100,000 inhabitants (95% confidence limits) attributable to the chronic effects of $PM_{2,5}$.

	Years of life lost					
	YoLL			**YoLL per 100,000**		
	central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg/m^3	4.17	1.43	6.85	0.53	0.18	0.83
By 3,5 µg/m^3	7.22	2.50	11.8	0.92	0.32	1.50