APHEIS Air Pollution and Health: A European Information System

Health Impact Assessment of Air Pollution

Tel-Aviv City Report

2002-2003

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TEL-AVIV CITY REPORT

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TEL-AVIV CITY REPORT

Summary of the main findings

Annual mean values of PM_{10} pollution in Tel-Aviv increased markedly between 1996 and 1998, from 56.4µg/m^3 to 66µg/m^3.
Recently, the WHO recommended the use of a correction factor of 1.3 for measured PM_{10}- values, due to use of continuous measurement methods, which underestimate the real PM_{10} values. According to this change, the annual mean value of PM_{10} in Tel-Aviv in 1998 was 85.8µg/m^3. This value is significantly higher than the current annual Israeli standard for PM_{10} (50µg/m^3) and the EC target standard for 2005 (40µg/m^3).

In 1998 no $PM_{2.5}$ measurements were carried out in Tel-Aviv. Recent measurements of the two fractions of PM (namely PM_{10} and $PM_{2.5}$), carried out in parallel in the same monitoring station in Tel-Aviv, enabled to calculate the local conversion factor for $PM_{2.5}$ from PM_{10}. We used this local conversion factor of 0.5 to calculate $PM_{2.5}$ values from the calculated PM_{10} values for 1998. The calculated annual $PM_{2.5}$ concentration for Tel-Aviv in 1998 was 42.9µg/m^3.

We analyzed the health outcomes attributable to exposure to both PM_{10} and $PM_{2.5}$.
We looked at different time frames of exposure and their health outcomes: short-term (ST: 0-1 days) cumulative (DL: distributed lag up to 40 days) and long-term (LT: years).
We studied different exposure scenarios in order to find out the benefits, in terms of lives saved, hospital admissions avoided and years of life saved, as a result of reduction of PM levels.
This analysis estimated for example, that the reduction of long-term $PM_{2.5}$ levels in Tel-Aviv from 42.9µg/m^3 to 20µg/m^3 could have saved 1,267 lives, including 750 cardio-pulmonary and 76 lung cancer lives in one year.
In terms of life expectancy, all other things being equal, if annual mean $PM_{2.5}$ levels (42.9 µg/m^3) would have been reduced to 15 µg/m^3, the 49.52 years of life expectancy in a person of 30 years old could be increased by 1.81 years, due to reduced risk of death (from all causes) in the district of Tel-Aviv.
If the annual mean of PM_{10} would have been kept under 40µg/m^3 (EC target standard for 2005) 1,536 death cases could be avoided and if daily PM_{10} levels would have been just under 50 µg/m^3, 343 cardiac and respiratory hospital admissions could have been avoided.

Compared to the 26 other Apheis cities, Tel-Aviv is the most polluted one in terms of particulate pollution; hence the severe public health consequences of this exposure.
For instance, regarding the benefits of the reduction of long term PM_{10} pollution to 40µg/m^3, Tel-Aviv would be the most beneficial city in the project. Similarly a reduction of long-term $PM_{2.5}$ concentrations to 15µg/m^3, would be most beneficial in terms of life expectancy.

Transportation constitutes the main source of air pollution in Tel-Aviv metropolitan area, while another important source is a 428megawatt oil-fired power plant.

Among the actions implemented by the authorities to reduce air pollution, is a gradual shift towards the use of new buses (Euro 2), which are both the most common mean of public transportation and the main polluters in Tel-Aviv. Among the planned actions to reduce air pollution is the development of a new public transportation system from the suburbs to the city center based on trains.

Background

- The main findings regarding Health Impact Assessment (HIA) for Tel-Aviv in 1996 are as follows: By using the Apheis scenarios for acute effects, we found for instance, that even a small reduction of daily PM_{10} levels above 50µg/m^3 to 50µg/m^3 could save 58 lives, 131 hospital admissions for cardiac diseases and 66 hospital admissions for respiratory diseases (for persons 65+ years). By using the scenarios for chronic effects we found that by reducing the annual mean of PM_{10} from 56.4µg/m^3 to 40µg/m^3 (EC target for 2005) we could save about 618 lives, while by reducing annual mean levels of PM_{10} to 20µg/m^3, we could save about 1315 lives.
- The objectives for Apheis 3 in 1998, were to reanalyse the health effects related to PM_{10} air pollution in Tel-Aviv similarly to 1996 and for the first time to analyze the health effects related to $PM_{2.5}$ air pollution. Additionally, to study further parameters such as long term effects in terms of Years of Life Lost (YoLL) and gain in life expectancy.
- The HIA (Health Impact Assessment) findings for 1996 were transferred to the relevant ministries (health and environment) and to the municipality of Tel-Aviv. None of them commented on the findings. The only response was from the public and the media.
- Air quality: The annual measured mean of PM_{10} in 1996 was 56.4µg/m^3, while in 1998 it was even higher: 66µg/m^3 – much higher than the 2005 EC limit value (40µg/m^3) for PM_{10}.
- Although the official agencies did not show any interest in the results achieved so far, it is very important to reiterate the analysis in order to draw public attention to the severe health impact of exposure to community air pollution.
- There were no major changes regarding local characteristics in Tel-Aviv district, e.g. population size, study area and economic activity between 1996 and 1998. Hence the results from the two studies are comparable.

Sources

- Principal sources of air pollution were described in detail in the previous Apheis city report (www.apheis.org). This is an update of the main sources of air pollution:
- Transportation continues to constitute the main source of air pollution in Tel-Aviv metropolitan area: about 65% of the emissions of nitrogen oxides, 90% of the emissions of carbon monoxide, 60% of the emissions of CO_2 and 68% of the emissions of hydrocarbons are emitted from cars.

Exposure data

- Regarding the air quality network: there were no major changes in the air quality network presented in the Apheis 2 report, that may affect exposure data for Apheis 3.
- The PM_{10} data from the same 2 monitoring stations used in Apheis 2, were used for Apheis 3 analysis. Hence the results from the two studies are comparable.

- Methods of measuring PM_{10} and $PM_{2.5}$: PM_{10} was measured continuously, using TEOM instruments, the measurements of which underestimate the real PM_{10} concentrations due to losses of volatile particulate matter. According to the recommendations of the WHO, we used a correction factor of 1.3 for the automatic measurements, in order to calculate the corrected PM_{10} concentrations in 1998.
- In order to calculate $PM_{2.5}$ values, we multiplied the corrected PM_{10} values by a local conversion factor of 0.5.
- Exposure data for Apheis 3:
    - Year of air pollution data – 1998.
    - Daily measured mean levels (SD) of PM_{10} were 66 (119) µg/m^3.
    - The levels of PM_{10} reached during the days with the lowest (5th percentile) and the highest (95th percentile) levels were: 29µg/m^3 and 105µg/m^3 respectively.
    - Number of days when air pollutants exceeded limit levels:

Air pollutant	PM_{10}
Number of days above	20 µg/m^3
	365
Number of days above	50 µg/m^3
	176

In Figures 1,2 and 3 the distribution of the actual measured PM_{10} values for the whole year, for summer and for winter are presented.

Figure 1. Distribution of PM10 - year

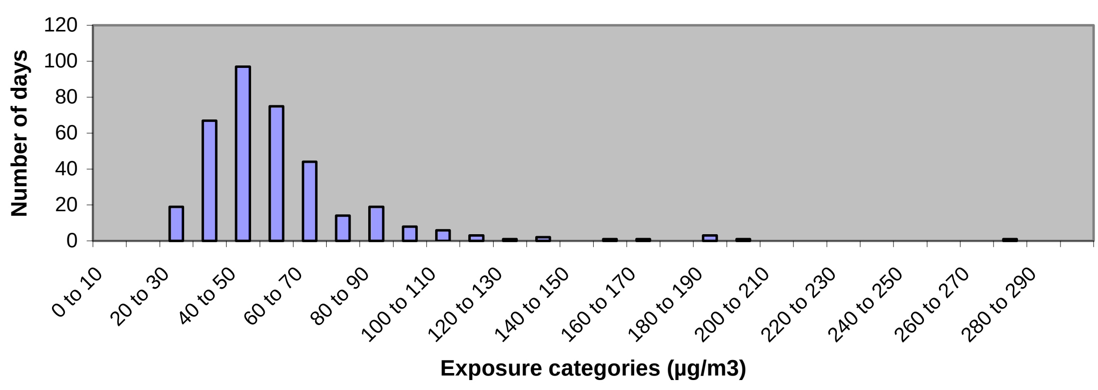

Figure 2. Distribution of PM10 - summer

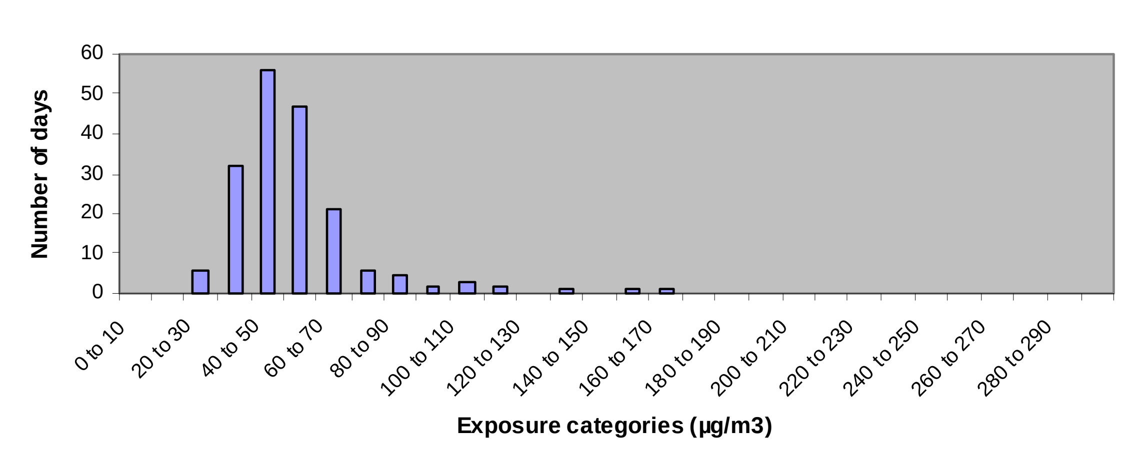

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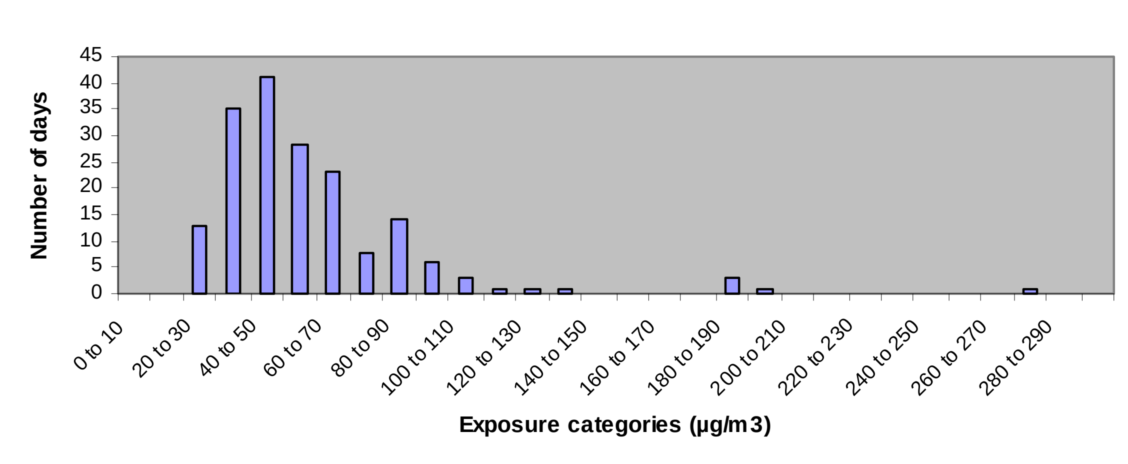
Figure 3. Distribution of PM10 - winter



The distributions of PM_{10} during winter, summer, and the whole year are very similar. The mode of the distributions is 40-50µg/m^3. Most of the values are in the range of 20-100µg/m^3; about five percent of the values are in the range of 100- 290.

Health data

- The source of mortality and hospital admissions data for the year 1998 is the department of information in the Ministry of Health.

- Data quality assessment: A quality control program for the health data exists in the department of information. Still, there are 4.6% missing data in basic cause of death. Codification is carried out using the ICD9.
- The age-standardised mortality rate in 1998 is: 845 per 100 000 inhabitants (using the European population for year 2000 [1]).
- In Table 1 the daily mean number and the annual rate per 100000 inhabitants for deaths and hospital admissions is presented. The diagnoses used for the different calculations of the health outcomes both for short term and for long-term health impact assessments (HIA) are presented for ICD9 and for ICD10.

Table 1. Daily mean number and annual rate per 100 000 of deaths and hospital admissions (1998)

Health outcome	ICD9	ICD10	Daily mean number	Annual number of cases per 100 000
Short term HIA				
All causes mortality (excluding external causes)*	< 800	A00-R99	24.42	810.45
Cardiovascular mortality	390-459	I00-I99	9.90	328.45
Respiratory mortality	460-519	J00-J99	1.8	59.73
Cardiac hospital admissions	390-429	I00-I52	60.82	2018.18
Respiratory hospital admissions	460-519	J00-J99	39.43	1308.45
Long term HIA				
All causes mortality	0-999	A00-Y98	27.48	912
Cardiopulmonary mortality	401-440 460-519	I10-I70 J00-J99	11.31	375.27
Lung cancer mortality	162	C33-C34	0.84	28

* For short and long term scenarios

Health impact assessment (HIA)

Different scenarios were used to evaluate short and long-term exposure to particulate pollution. In the district of Tel-Aviv, these scenarios were built for two indicators of this particulate pollution: 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 we add findings of these indicators 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 2).

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

Table 2. Summary SHORT-TERM Health impact assessment (HIA)

	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) All ages, cardiovascular mortality All ages, respiratory mortality All ages, cardiac hospital admissions All ages, respiratory hospital admissions	< 800 390-459 460-519 390-429 460-519	A00-R99 I00-I99 J00-J99 I00-I52 J00-J99	French PSAS-9 Excel spreadsheet	WHO, 2003: 1.006 (1.004 - 1.008) WHO, 2003: 1.009 (1.005 - 1.013) WHO, 2003: 1.013 (1.005 - 1.021) Le Tertre et al. 2002: 1.006 (1.003 - 1.009) Apheis 3: 1.0114 (1.0062 - 1.0167)
BS	All ages, all causes mortality (excluding external causes) All ages, cardiovascular mortality All ages, respiratory mortality All ages, cardiac hospital admissions All ages, respiratory hospital admissions	< 800 390-459 460-519 390-429 460-519	A00-R99 I00-I99 J00-J99 I00-I52 J00-J99	French PSAS-9 Excel spreadsheet	WHO, 2003: 1.006 (1.004 - 1.009) WHO, 2003: 1.004 (1.002 - 1.007) WHO, 2003: 1.006 (0.998 - 1.015) Le Tertre etal. 2002:1.011 (1.004 - 1.019) Apheis 3: 1.0030 (0.9985 -1.0075)
PM10 Distributed lag (40 days)	All ages, all causes mortality (excluding external causes) All ages, cardiovascular mortality All ages, respiratory mortality	< 800 390-459 460-519	A00-R99 I00-I99 J00-J99	French PSAS-9 Excel spreadsheet	Zanobetti et al. 2002: 1.01227 (1.0081 - 1.0164) Zanobetti et al. 2003: 1.01969 (1.0139 - 1.0255) Zanobetti et al. 2003: 1.04206 (1.0109 - 1.0742)
		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 2 (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	–	–

Also different approaches were used to describe the impacts:
For PM_{10}, short and long-term findings are expressed in terms of number of attributed deaths per year. For short-term also the number of attributed hospital admissions were calculated.
For PM $_{2.5}$, long-term findings are expressed in terms of:
- Number of attributed deaths per year.
- Number of expected years of life lost due to deaths in one year.
- Expected gain in life expectancy.

1. Health Impact Assessment (HIA) Scenarios

1.1. Short-term scenarios

We used the following scenarios to estimate the acute effects of short-term exposure to PM_{10} on mortality and hospital admissions over one year (using the measured PM_{10} values).

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**

We used three scenarios 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.
- Reduction of PM_{10} levels to a 24-hour value of 20 µg/m^3 on all days exceeding this value.
- Reduction of PM_{10} by 5 µg/m^3 of all the 24-hour values.

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

We used the same scenarios as above 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 a local estimate in the combined (meta-analytic) one.

1.2. Long-term scenarios

Long-term HIA scenarios for PM_{10}

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

- Reduction of the annual mean value of PM_{10} to a level of 40 µg/m^3 (EC 2005 limit value for PM_{10})
- Reduction of the annual mean value of PM_{10} to a level of 20 µg/m^3 (EC 2010 limit value for PM_{10})
- Reduction of the annual mean value of PM_{10} by 5 µg/m^3.

Long term HIA for PM2.5

We estimated chronic effects of $PM_{2.5}$ in Tel-Aviv district population over 30 years old as impacts on mortality due to all causes, due to cardiopulmonary and due to lung cancer deaths, using converted PM_{10} values.

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
- Reduction of the annual mean value of $PM_{2.5}$ to a level of 15 µg/m^3
- Reduction by 3.5 µg/m^3 in the annual mean value of $PM_{2.5}$.

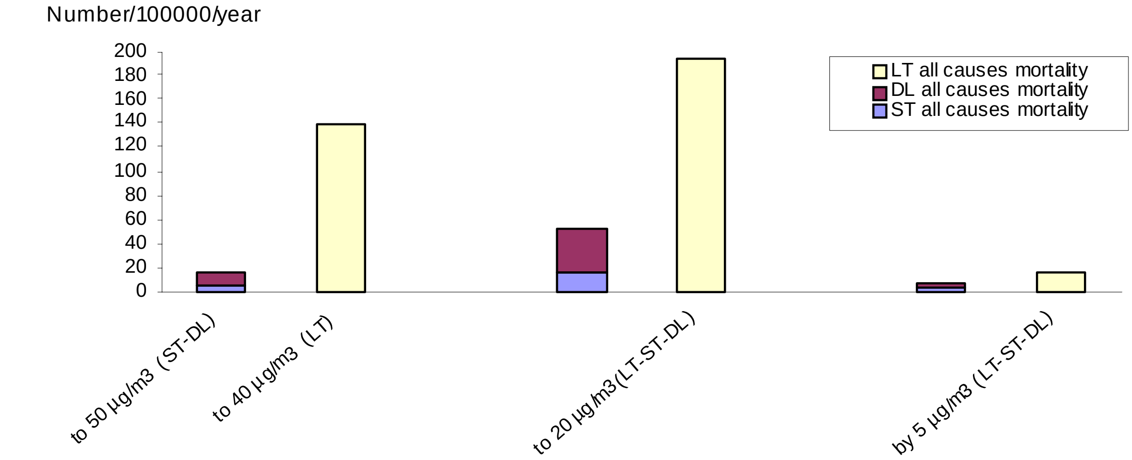
2. PM_{10} findings

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

2.1.1. Mortality findings

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

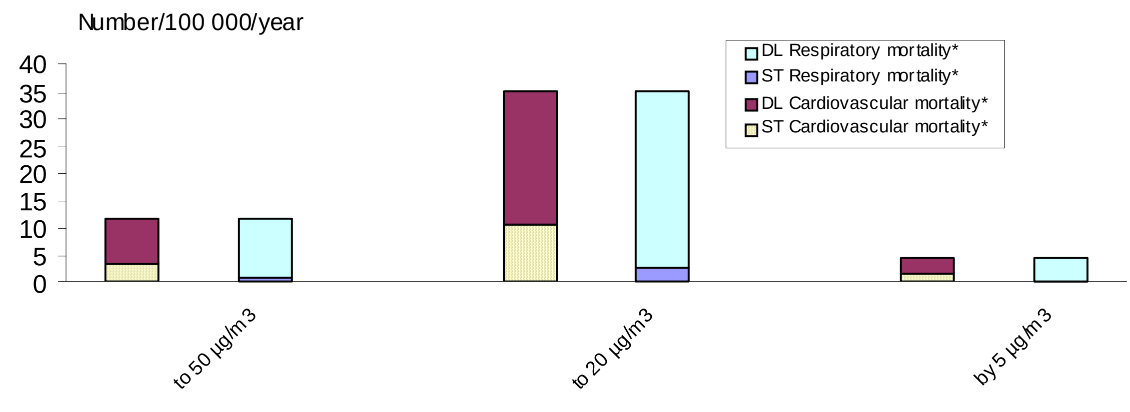
Figure 4. PM10: reductions to 50/40-20-by 5 µg/m^3. Short term (ST), cumulative (DL), long term (LT) health impact on all causes mortality (ICD 9 <800)



- PM_{10} data for 1998, mortality data for 1998

In Figure 4 the potential benefits of reducing PM_{10} levels during the different time frames - short-term (ST), cumulative (DL) and long-term (LT) are presented in terms of number of lives saved per 100000 Population, due to all cause mortality.
As can be seen from Figure 4, about 140 death cases per 100000 inhabitants can be avoided by reducing annual levels of PM_{10} to 40µg/m^3, and by reducing annual PM_{10} levels by just 5 µg/m^3, 10 cases per 100000 inhabitants can be saved.
The reduction of all causes mortality in the cumulative time frame (DL-40 days distributed lag), is about twice as high as in the short-term (0-1 days) time frame, in all the PM_{10} scenarios (Figure 4).

Figure 5. PM_{10}: reductions to 50-20-by 5 µg/m^3. Short term (ST), cumulative (DL) health impact on specific mortality



*Cardiovascular mortality (ICD9 390-459), respiratory mortality (ICD9 460-519).
** PM_{10} data for 1998, mortality data for 1998

In figure 5 the potential benefits of the reduction of PM_{10} levels in the short-term (ST) and in the cumulative (DL) time frames are presented in terms of the number of lives saved per 100000 inhabitants due to respiratory and cardio-vascular mortality.

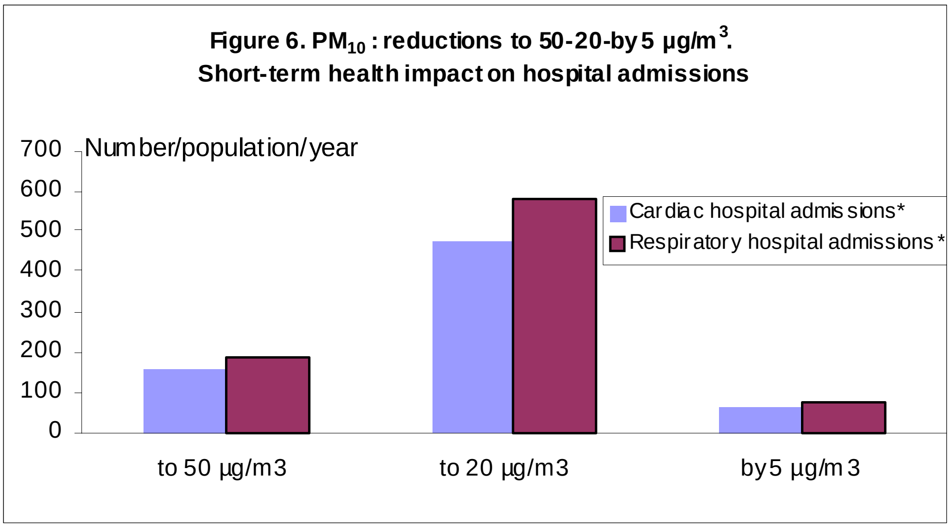
The reduction of cardio-vascular and of respiratory mortality in the cumulative time-frame is about three times higher than in the short term time frame in all the PM_{10} scenarios (Figure 5).

Most studies of air pollution and daily deaths have related pollution levels to death in the day or two immediately following exposure. Recently, several studies have looked at longer follow up periods *(Schwartz, Dominici, Zanobetti)* and reported that the cumulative effect was more than twice that found using only two days of follow up. These results, using distributed lag models (Schwartz) are the primary basis for our estimates of the delayed short-term effects of changes in air pollution concentrations.

Similarly to these results we found the larger impact on mortality of longer follow-up periods (up to 40 days) compared to short-term periods (0-1 lag) for the different PM_{10} scenarios and for total as well as respiratory and cardio-vascular mortality.

2.1.2. Hospital admissions findings

We estimated the acute effects of short-term exposure to PM_{10} on cardiac and respiratory hospital-admissions over one year. The HIA (health impact assessment) on hospital admissions is presented in Figure 6.

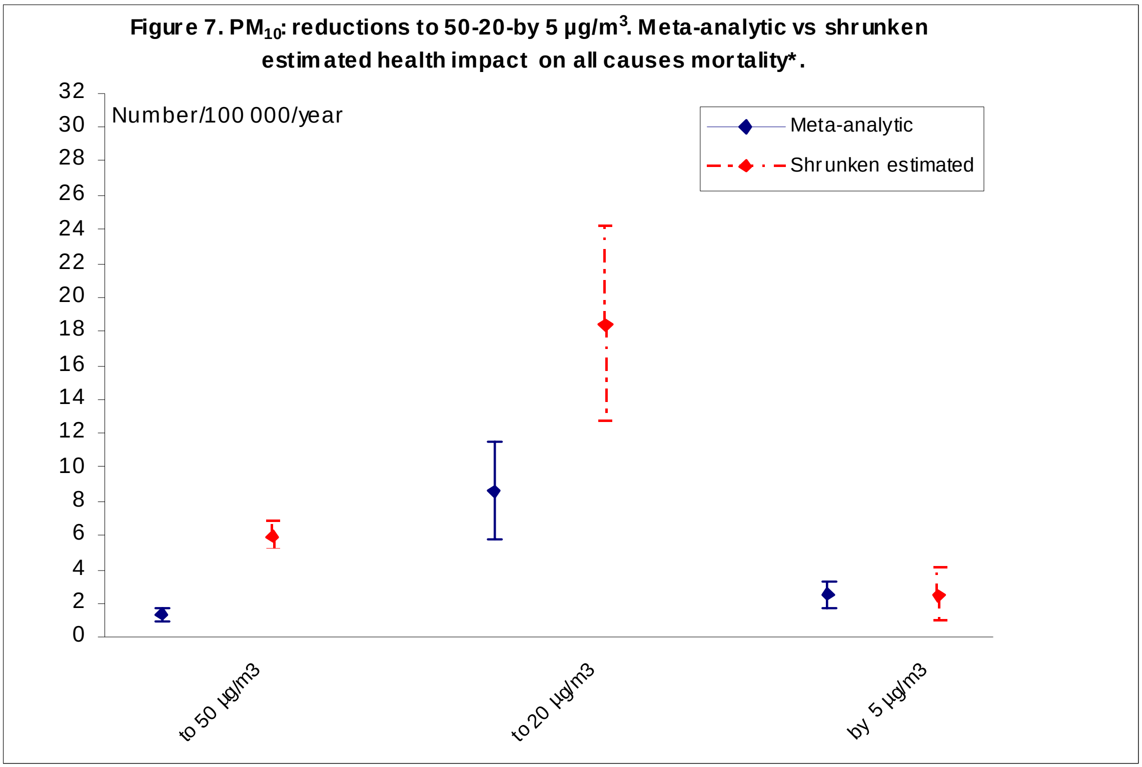


* Cardiac (ICD9 390-429) and respiratory hospital admissions (ICD9 460-519)
** PM_{10} data for 1998, hospital admissions data for 1998

As can be seen from Figure 6 the short-term impact of air pollution reductions on cardiac hospital admissions is somewhat lower than that on respiratory hospital admissions in the three studied scenarios.
For instance, a reduction of daily PM_{10} levels higher than 20µg/m^3 to 20µg/m^3 could have saved 475 cardiac- and 579 respiratory hospital admissions.

2.2. Combined local and meta-analytic estimates (shrunken estimates – SE) for the health effects of PM_{10}

We combined local and meta-analytic estimates (shrunken estimates-SE) to calculate the acute health effects of PM_{10} on all causes of death (excluding external causes) over one year. The shrunken estimate has the property to derive the overall estimate at the local level by combining information from the city-specific estimate and the overall one and can be considered as a weighted mean between these two estimates.
Figure 7 compares short-term (0-1 days) health impact assessment of PM_{10} with that of the combined estimate.



* All causes mortality excluding external causes (ICD9 < 800)
** PM_{10} data for 1998, mortality data for 1998

The combined local and meta-analytic estimates (SE) for the health impact assessment for Tel-Aviv for both the 50µg/m^3 and 20µg/m^3 PM_{10} scenarios are markedly higher than the meta-analytic estimates. However, for the scenario of a reduction of PM_{10} levels by 5µg/m^3, the combined local HIA is similar to the meta-analytic HIA.

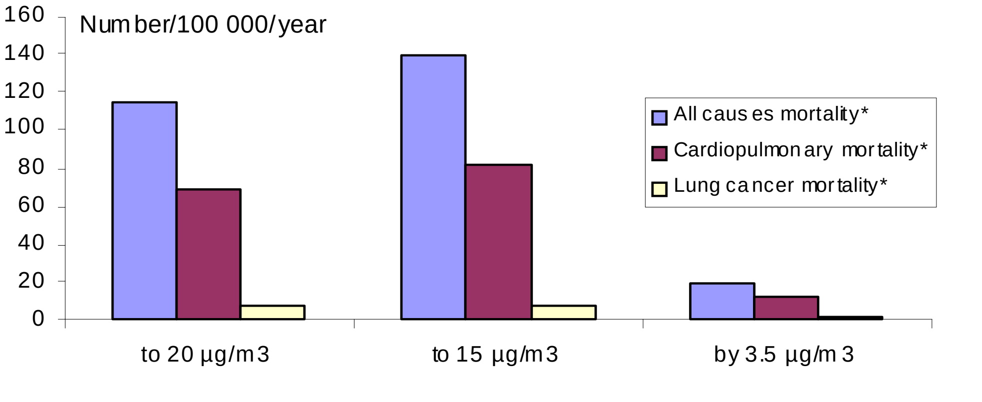
3. $PM_{2.5}$ findings

3.1. Long-Term attributable cases for $PM_{2.5}$.

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

Figure 8 presents the attributable number of all causes, cardiopulmonary and lung cancer deaths expressed as per 100 000 inhabitants.
As expected, the stricter the target of $PM_{2.5}$ reduction, the larger the number of lives saved for all causes-, for cardiopulmonary- and for lung-cancer mortality.
For instance a reduction of annual mean value of $PM_{2.5}$ from 42.9µg/m^3 to 20 µg/m^3 could save 115/100000 lives due to all causes, 68/100000 cardio-pulmonary mortality cases and about 8/100000 lung cancer fatalities.
For Tel-Aviv population this means a potential reduction of 1267 death cases, 750 cardiopulmonary deaths and 76 lung cancer death cases.

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

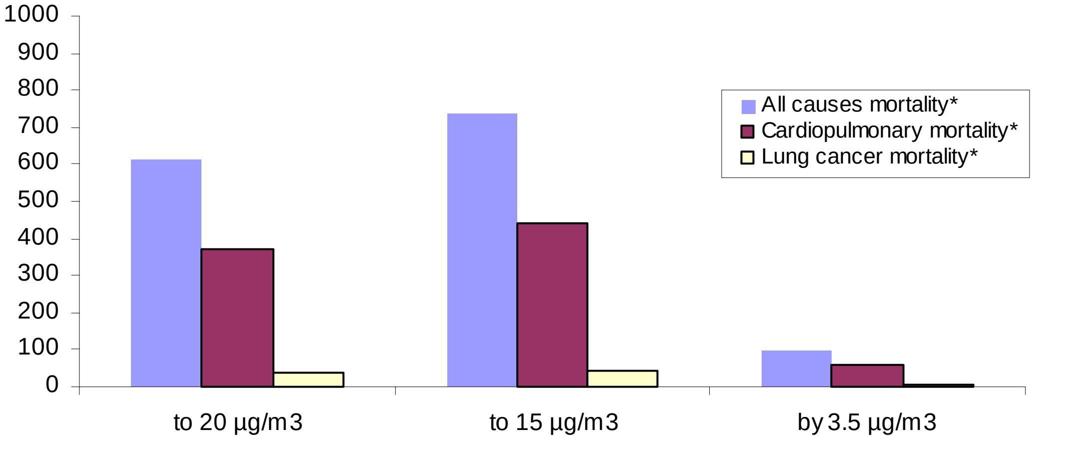


* All causes mortality (ICD9 0-999), cardiopulmonary mortality (ICD9 401-440 and 460-519), lung cancer mortality (ICD9 162).
** PM $_{2.5}$ data for 1998, mortality data for 1998

3.2. Years of life lost (YoLL) for $PM_{2.5}$

We estimated the years of life lost attributable to the chronic effects of $PM_{2.5}$ using both the exposure and the mortality data for 1998.
Figure 9 presents the years of life lost for all causes, cardiopulmonary and lung cancer deaths for people 30 years of age or older in the population of Tel-Aviv in the first year of calculation.

Figure 9. $PM_{2.5}$: reductions to 20-15-by 3.5 µg/m^3. Expected years of life lost due to the deaths in 1998 for total and specific mortality for >30 years



* All causes mortality (ICD9 0-999), cardiopulmonary mortality (ICD9 401-440 and 460-519), lung cancer mortality (ICD9 162).
** PM $_{2.5}$ data for 1998, mortality data for 1998

As can be seen from figure 9, for all causes of deaths, all other things being equal, reduction of $PM_{2.5}$ to 20µg/m^3 could have saved 616 years of expected life in people older than 30 years in Tel-Aviv metropolitan. For cardiopulmonary mortality, this number would be about 370 and for lung cancer mortality about 38.

3.3. Gain in life expectancy

Table 3. Life expectancy and its possible increase by reduction of air pollution to 15µg/m3 in Tel-Aviv

		Expected gain in life expectancy		
Age	Life expectancy	Mean	Low estimate	High estimate
At birth	78.57	1.78	0.47	3.10
30	49.52	1.81	0.47	3.14
65	17.68	1.48	0.39	2.59

As can be seen from table 3, in terms of life expectancy, all other things being equal, if annual mean $PM_{2.5}$ levels (42.9 µg/m^3) would be reduced to 15 µg/m^3, the 49.52 years of life expectancy in a person of 30 years old would be increased by 1.81 years, due to reduced risk of death from all causes in the city of Tel-Aviv.

Interpretation of findings

- **Exposure assessment for 1998:**

- There were no major changes in the air pollution network (as presented in the Apheis 2 report), which may affect exposure data for Apheis 3. The PM_{10} data from the same 2 monitoring stations used in Apheis 2, were used for Apheis 3 analysis. PM_{10} was continuously measured using Teom equipment. According to WHO guidelines, we used a correction factor of 1.3 for the automatic measurements of PM_{10} carried out in 1998, in order to compensate for losses of volatile particulate matter. Since no measurements of $PM_{2.5}$ were carried out in 1998, we used a local conversion factor of 0.5 to calculate $PM_{2.5}$ from corrected PM_{10} measurements.
  Measured daily mean levels (SD) of PM_{10} were 66 (119) µg/m^3. The levels of PM_{10} reached during the days with the lowest (5th percentile) and the highest (95th Percentile) levels were 29µg/m^3 and 105µg/m^3 respectively. The number of days on which air pollutants exceeded limit levels were as follows: levels were above 20µg/m^3 on 365 days and on 176 days the levels were above 50µg/m^3.

- **Health outcomes for 1998:**

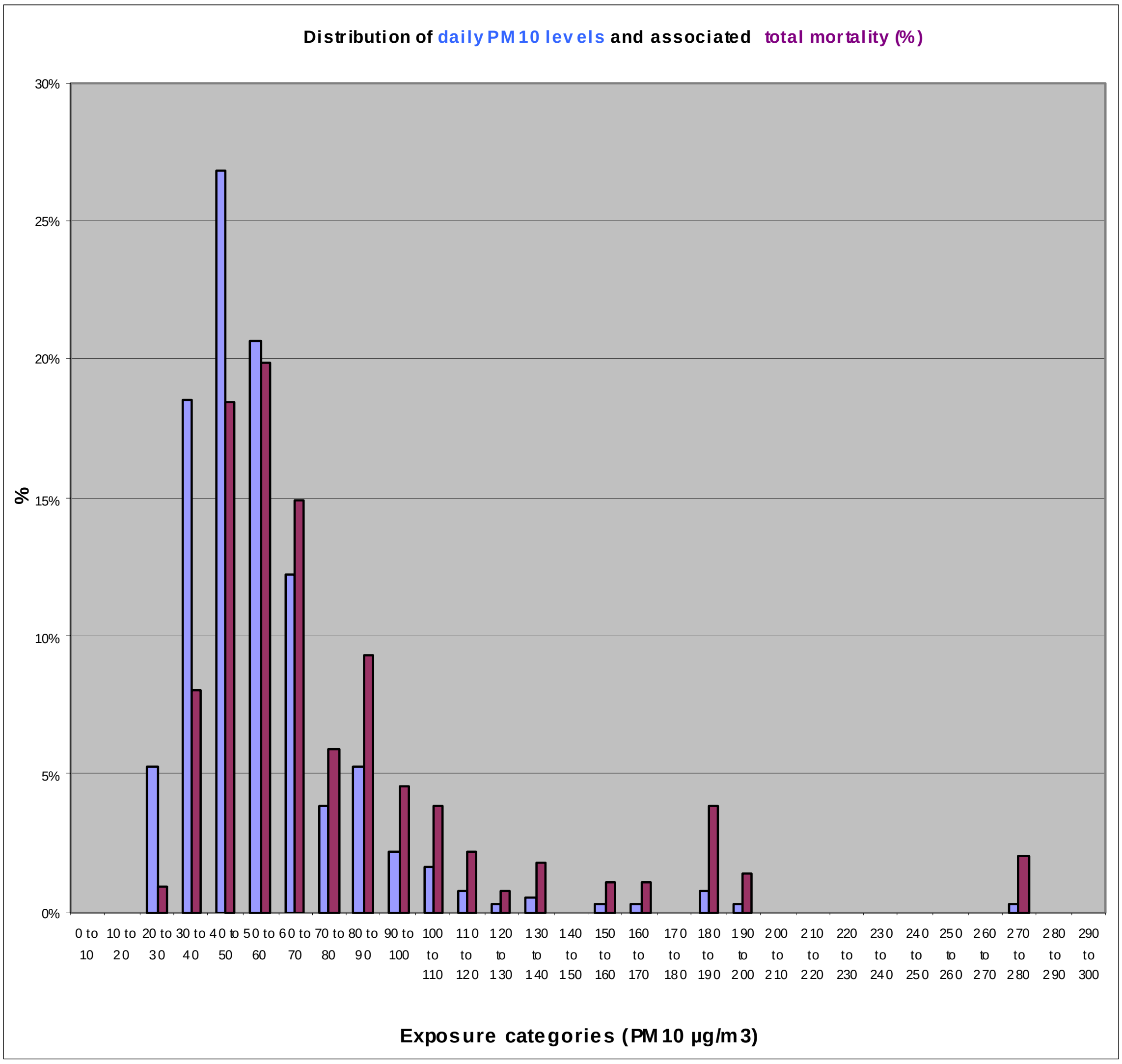
- For long-term scenarios, the reduction of annual corrected mean values of PM_{10} to levels of 20µg/m^3 (EC target for 2010) and 40µg/m^3 (EC target for 2005) could have saved 194 and 140 lives per 100,000 inhabitants, respectively (Appendix Table 9). For the population of Tel-Aviv, this means, saving 2131 and 1536 lives, respectively. The reduction of converted annual mean values of $PM_{2.5}$ to levels of

15μg/m^3 and 20μg/m^3 could have saved 139 and 115 lives per 100,000 inhabitants, respectively (Appendix Table 10). For the population of Tel-Aviv, this means, saving 1529 and 1267 lives, respectively.

- Differences between short and distributed lag findings for PM_{10} are as follows: the reduction of all causes mortality up to 40 days (DL distributed lag) is about twice as high as for short-term (0-1 lag) in the different scenarios (figure 4). The reduction of cardio-vascular and of respiratory mortality up to 40 days (DL distributed lag) is about three times higher than the short-term (0-1 lag) in the different scenarios (figure 5).
- Findings for $PM_{2.5}$ in terms of attributable cases, life expectancy and YoLL are as follows: as can be seen from figure 9, for all causes of deaths, all other things being equal, reduction of $PM_{2.5}$ to 20μg/m^3 in 1998 could have saved 616 years of expected life in people older than 30 years in Tel-Aviv metropolitan. For cardiopulmonary mortality, this number would be 370 and for lung cancer mortality - 38.

  In terms of life expectancy, all other things being equal, if annual mean $PM_{2.5}$ levels (42.9 μg/m^3) would be reduced to 15 μg/m^3, the 49.52 years of life expectancy in a person of 30 years old would be increased by 1.81 years, due to reduced risk of death from all causes in the city of Tel-Aviv.
- According to figure 10, most mortality cases occur during days with PM_{10} levels in the relatively lower range of 23-105 μg/m^3; still about 15% of the cases occur during PM_{10} peaks (5% of the days).

Figure 10. Short term distribution of PM_{10} levels and associated percentage of mortality cases.



General comments and conclusions

- The new evidence provided by the third phase of the Apheis-programm confirmed the findings of Apheis 2 , that air pollution continues to pose a significant threat to public health in urban environments in Europe.
- Although the official agencies did not show any interest in the disturbing results achieved so far, it is very important to reiterate the analysis in order to draw public attention to the serious health impact of exposure to community air pollution.
- We hope that the current results will draw more attention from the relevant authorities, since the health impact of exposure to air pollution in Tel-Aviv is very severe.
- Since currently there are no allocated resources to continue the Apheis surveillance system, we are quite anxious about its future in Tel-Aviv.

Appendix

1. Tables for PM_{10} findings

1.1 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 all causes (ICD9 < 800). Potential benefits of reducing daily PM_{10} levels (1998) 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					
Scenarios	Number of days per year exceeding 20 and 50 µg/m^3	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
20 µg/m^3	365	190.90	126.66	255.76	17.35	11.51	23.25
50 µg/m^3	176	61.50	40.78	82.44	5.59	3.71	7.49
By 5 µg/m^3	NA*	25.75	17.18	34.32	2.38	1.56	3.12

**NA: not applicable*

Table 2. Cardiovascular deaths (ICD9 390-459). Potential benefits of reducing daily PM_{10} levels (1998) 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					
Scenarios	Number of days per year exceeding 20 and 50 µg/m^3	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
20 µg/m^3	365	115.36	63.48	168.27	10.49	5.77	15.30
50 µg/m^3	176	37.53	20.63	54.81	3.41	1.88	4.98
By 5 µg/m^3	NA*	15.37	8.55	22.18	1.40	0.78	2.02

**NA: not applicable*

Table 3. Respiratory deaths (ICD9 460-519). Potential benefits of reducing daily PM_{10} levels (1998) 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					
Scenarios	**Number of days per year exceeding 20 and 50 µg/m^3**	**N° of deaths central**	**N° of deaths lower**	**N° of deaths upper**	**N° of deaths per 100 000 central**	**N° of deaths per 100 000 lower**	**N° of deaths per 100 000 upper**
20 µg/m^3	365	30.05	11.34	49.52	2.73	1.03	4.50
50 µg/m^3	176	9.91	3.73	16.37	0.90	0.34	1.49
By 5 µg/m^3	NA*	3.94	1.52	6.35	0.36	0.14	0.58

**NA: not applicable*

Table 4. Cardiac (ICD9 390-429) and respiratory (ICD9 460-519) hospital admissions. Potential benefits of reducing daily PM_{10} levels (1998) 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 PM_{10}

		Attributable cases per year		
Scenarios	**Number of days per year exceeding 20 and 50 µg/m^3**	**N° of hospital admissions central**	**N° of hospital admissions lower**	**N° of hospital admissions upper**
Hospital admissions for cardiac diseases (all ages)				
20 µg/m^3	365	475.44	236.02	718.35
50 µg/m^3	176	153.16	75.97	231.63
By 5 µg/m^3	NA*	64.14	32.09	96.14
Hospital admissions for respiratory diseases (all ages)				
20 µg/m^3	365	579.14	311.02	859.56
50 µg/m^3	176	189.91	101.82	282.35
By 5 µg/m^3	NA*	76.40	41.60	111.77

**NA: not applicable*

1.2. 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). Potential benefits of reducing daily PM_{10} levels (1998) above 20 to 20 µg/m³, above 50 to 50 µg/m³ and all days by 5 µg/m³. Absolute number and number per 100 000 inhabitants (95% confidence limits) attributable to the effects of PM_{10}

		Attributable cases per year					
Scenarios	Number of days per year exceeding 20 and 50 µg/m³	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
20 µg/m³	365	385.37	251.83	520.36	35.03	22.89	47.31
50 µg/m³	176	126.73	82.70	171.36	11.52	7.52	15.58
By 5 µg/m³	NA*	50.65	33.47	67.63	4.60	3.04	6.15

**NA: not applicable*

Table 6. Cumulative health effects of PM_{10} up to 40 days and cardiovascular deaths (ICD9 390-459) (1998). Potential benefits of reducing daily PM_{10} levels (1998) above 20 to 20 µg/m³, above 50 to 50 µg/m³ and all days by 5 µg/m³. Absolute number and number per 100 000 inhabitants (95% confidence limits) attributable to the effects of PM_{10}

		Attributable cases per year					
Scenarios	Number of days per year exceeding 20 and 50 µg/m³	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
20 µg/m³	365	191.91	133.53	252.23	17.45	12.14	22.93
50 µg/m³	176	64.67	44.91	85.18	5.88	4.08	7.74
By 5 µg/m³	NA*	24.45	17.28	31.62	2.22	1.57	2.87

**NA: not applicable*

Table 7. Cumulative health effects of PM_{10} up to 40 days and respiratory deaths (ICD9 460-519). Potential benefits of reducing daily PM_{10} levels (1998) 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 effects of PM_{10}

		Attributable cases per year					
Scenarios	**Number of days per year exceeding 20 and 50 µg/m^3**	**N° of deaths central**	**N° of deaths lower**	**N° of deaths upper**	**N° of deaths per 100 000 central**	**N° of deaths per 100 000 lower**	**N° of deaths per 100 000 upper**
20 µg/m^3	365	92.22	22.05	178.69	8.38	2.00	16.24
50 µg/m^3	176	33.47	7.91	65.95	3.04	0.72	6.00
By 5 µg/m^3	NA*	10.67	2.79	18.67	0.97	0.25	1.70

**NA: not applicable*

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

Table 8 presents the attributable number of all causes of deaths expressed as absolute numbers and as rates per 100 000 inhabitants.

Table 8. Combined local and meta-analytic estimates for the health effects of PM_{10} and all causes of deaths (ICD9 < 800). Potential benefits of reducing daily PM_{10} levels (1998) 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					
Scenarios	**Number of days per year exceeding 20 and 50 µg/m^3**	**N° of deaths central**	**N° of deaths lower**	**N° of deaths upper**	**N° of deaths per 100 000 central**	**N° of deaths per 100 000 lower**	**N° of deaths per 100 000 upper**
20 µg/m^3	365	201.92	66.91	340.32	18.36	6.08	30.94
50 µg/m^3	176	65.12	21.55	109.90	5.92	1.96	9.99
By 5 µg/m^3	NA*	27.20	9.11	45.33	2.47	0.82	4.12

**NA: not applicable*

1.4 Long term health effects of 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). Potential benefits of reducing annual mean values of PM_{10} (1998) 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					
	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
20 µg/m^3	2131.53	1229.62	3178.68	193.78	111.78	288.97
40 µg/m^3	1535.76	901.54	2247.81	139.61	81.96	204.35
By 5 µg/m^3	185.67	112.73	262.25	16.88	10.25	23.84

2. Tables for $PM_{2.5}$ findings

2.1. Long term health effects of $PM_{2.5}$.

Tables 10,11,12 present the attributable number of all causes, cardiopulmonary and lung cancer deaths expressed as absolute numbers and as rates per 100 000 inhabitants.

Table 10. Deaths all causes (ICD9 0-999). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) 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					
	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
15 µg/m^3	1527.13	376.41	2830.00	138.83	34.22	257.3
20 µg/m^3	1267.49	316.01	2321.12	115.23	28.73	211.01
By 3,5 µg/m^3	208.97	54.38	366.33	19.00	4.94	33.30

Table 11. Cardiopulmonary deaths (ICD9 401-440 and 460-519). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) 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					
	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
15 µg/m^3	897.61	300.29	1597.78	81.60	27.30	145.25
20 µg/m^3	750.12	254.73	1314.48	68.19	23.16	119.50
By 3,5 µg/m^3	127.02	45.59	210.29	11.55	4.14	19.12

Table12. Lung cancer deaths (ICD9 162). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) 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					
	N° of deaths central	N° of deaths lower	N° of deaths upper	N° of deaths per 100 000 central	N° of deaths per 100 000 lower	N° of deaths per 100 000 upper
15 µg/m^3	90.10	27.30	169.15	8.19	2.48	15.38
20 µg/m^3	75.94	23.53	139.21	7.90	2.14	12.66
By 3,5 µg/m^3	13.30	4.47	22.40	1.21	0.41	2.04

2.2. Long-term health effects of PM $_{2.5}$: Years of Life Lost

Tables 13,14,15 present the years of life lost of all causes, cardiopulmonary and lung cancer deaths expressed as absolute numbers and as rates per 100 000 inhabitants.

Table 13. Deaths all causes >30 years, male and female, for one year (ICD9 0-999). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) to levels of 15 and 20 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 central	YoLL lower	YoLL upper	YoLL per 100 000 central	YoLL per 100 000 lower	YoLL per 100 000 upper
15 µg/m^3	738.97	205.45	1213.12	64.57	17.95	106.01
20 µg/m^3	615.50	169.39	1020.47	53.78	14.80	89.17
By 3,5 µg/m^3	98.93	26.15	170.64	8.64	2.29	14.91

Table14. **Cardiopulmonary deaths >30 years, male and female, for one year (ICD9 401-440 and 460-519). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) to levels of 15 and 20 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**	**YoLL**	**YoLL per 100 000**	**YoLL per 100 000**	**YoLL per 100 000**
	central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg/m^3	440.91	172.18	670.93	38.53	15.05	58.63
20 µg/m^3	369.81	142.52	569.86	32.32	12.45	49.80
By 3,5 µg/m^3	61.12	22.35	99.15	5.34	1.95	8.66

Table 15. **Lung cancer deaths >30 years, male and female, for one year (ICD9 162). Potential benefits of reducing annual mean values of $PM_{2,5}$ (1998) to levels of 15 and 20 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**	**YoLL**	**YoLL per 100 000**	**YoLL per 100 000**	**YoLL per 100 000**
	central	**lower**	**upper**	**central**	**lower**	**upper**
15 µg/m^3	45.15	17.23	67.25	3.95	1.51	5.88
20 µg/m^3	38.19	14.30	57.91	3.34	1.25	5.06
By 3,5 µg/m^3	6.54	2.26	10.69	0.57	0.20	0.93