HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Gothenburg

Summary of main findings for **Gothenburg**

In 2002 the PM_{10} annual mean (SD) as urban background level was 21(10) µg/m^3, which is in line with the 1999/30/EC Directive limit value for 2010 (20 µg/m^3), and below that established for 2005 (40 µg/m^3). For the summer period of the same year, the mean (SD), P5 (5th percentile) and P95 of the maximum daily 8-hour moving average concentration of ozone (O_3) were 79 (18), 51 and 111 µg/m^3.

Regarding children, infant mortality in Europe is quite low and consequently, the expected attributable number of deaths related to air pollution is also very low. All other things being equal, the reduction of the annual average levels of PM_{10} with 5 µg/m^3 would statistically prevent a total of 0.07 postneonatal deaths per year. Reducing PM_{10} daily mean values by 5 µg/m^3 would also prevent 4 hospital respiratory admissions per year within the age group 0-15 years.

As far as short-term effects of O_3 in summer are concerned, all other things being equal, each reduction by 10 µg/m^3 of the daily maximum 8-hour moving average concentrations would prevent 7 preterm deaths per year in the general population in the study area, 4.5 from cardiovascular diseases, and 2 from respiratory causes. In terms of hospital admissions, this would each year represent 0.6 respiratory admissions in the adult population below and 5 in the population over 64 years.

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

Health outcome	Population	Pollutant	Period	Mean type	RR (for 10 µg.m^3 increase)	*References*	Number of attributable cases by scenario[1]	
Mortality							**Ozone: Reduction by 10 µg.m^3**	**PM10: Reduction by 5 µg/m^3**
Total mortality excluding external causes (ICD9 < 800 - ICD10 A00-R99)	All ages	O_3 8h max	Summer[2]	Daily	1.0031 (1.0017-1.0052)	Gryparis et al 2004	6.99	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)					1.0046 (1.0022-0.0073)		4.58	
Respiratory mortality (ICD9 460-519 – ICD10 J00-J99)					1.0113 (1.0074-1.0151)		1.85	
Total postneonatal mortality	1 month- 1 year	Corrected PM_{10}[3]	Year	Annual	1.048 (1.022-1.075)	Lacasaña et al 2005		0.07
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.216 (1.102-1.342)			0.00
Postneonatal Sudden Infant Death Syndrom Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		0.06
Morbidity								
Emergency room visits for asthma (ICD-9 codes 493, ICD-10 codes J45, J46)	< 18 years	O_3 1h max	Year	Daily	1.0115 (1.0067-1.0163)	CARB 2004	2.48	
Cough	< 18 years	Measured PM_{10}			1.0407 (1.0202-1.0511)	Ward and Ayres 2004		not available
Lower respiratory symptoms LRS	< 18 years	Measured PM_{10}			1.0407 (1.0202 -1.617)	Ward and Ayres 2004		not available
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	< 15 years	Measured PM_{10}			1.010 (0.998-1.021)	Anderson et al 2004		3.82
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)		0.62	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		4.97	

[1] For ozone: absolute reduction by 10 µg/m^3. For PM_{10} absolute reduction by 5 µg/m^3.

[2] Definition of summer period : 01 April – 30 September

[3] PM_{10} reference papers for HIA on postneonatal mortality use gravimetric methods to measure PM_{10}. If the local air quality network uses automatic methods (TEOM or other) a correction factor is required to compensate for loss of volatile compounds: if available, a local correction factor recommended by the air quality network or, by default, the European factor 1.3.

Introduction

The study area includes the major part of the population in Gothenburg with exclusion of some of the most rural areas.

Gothenburg is the largest metropolitan area on the west coast of Sweden with a total population of roughly 475 000 (2002). Approximately 16% of the population is younger then 14 years of age and 15% is older than 64 years. The population density is 1637 inhab/km^2 when the most rural areas, *i.e.* islands (except Hisingen), are excluded.

The main cause of death among the adult population in Sweden are cardiovascular disease, with approximately 45% of the men and 44% of the woman dying with this cause of death. Since 1990 the trend has been positive with a decreasing number deaths in cardio-vascular disease, which has resulted in an increase in expected life length from 1990 until 2004 with 3 years among men and 2 years among woman.

From an international point of view, children’s health is very good in Sweden. The mortality during the first year of life has decreased with 50% from 1984 until 2004 to an average of 3.1 per 1000 born alive. Vaccination programmes have been sussessful, resulting in the disapperance of a number of serious infectious diseases such as tetanus, diphtheria, polio, measles, German measles and whooping cough. Since many years Sweden is one of the countries with the lowest infant mortality in the world. Health in Swedish children has also been improved by almost complete elimination of conditions such as malnutrition and vitamin deficiency.

However, the number of children and adults with allergies has more than doubled in Sweden over the last few decades, as in other parts of Europe. More than one in four children today suffer from an allergic disease with symptoms. Most children with allergic diseases have their onset in the first four-five years of life.

The urban background levels of air pollution in the study area are from a European perspective relatively low. Transportation, including ferries and ships, contributes to the major part of the local emissions, while heating and industry contributes more moderately. At street level vehicle traffic is the major contributor to coarse particles and gaseous pollutants but long distance transport of air pollutants from other parts of Europe is also important, especially for the urban background levels of fine particles and ozone.

Previous corresponding health impact assessments (HIA) has been carried out for this area within the framework of the APHEIS year 2 and 3.

This report presents the descriptive data on air pollution and health outcomes together with the results from the HIA calculations made within the work package WP5 of ENHIS-1 project (www.enhis.com).

Sources of air pollution

During the past 30 years there has been a marked improvement of the air in Gothenburg. In the past decades, the major source of pollution was sulphur dioxide generated through different kind of combustion, but also black smoke (BS), nitrogen dioxide and volatile organic compounds (VOC) were emitted in considerable amounts. In 1980, the yearly amount of emitted sulphur dioxide in Göteborg was estimated to 15 000 tons, while the same figure in 2000 was estimated to 2000 ton. The main reason for this dramatic decrease is several successful direct or indirect strategies for reducing air pollution.

The development of district heating in combination with regulations on sulphur levels in heavy oils was an important factor for reducing the levels of emitted SO_2. Also, the escalating prices on oil lead to development of several energy saving strategies, which lowered the over all consumption of energy.

In 1989, the Swedish government stated limits regarding emissions from personal vehicles that in practice could not be fulfilled without catalytic engines, and in 1992/1993 limitations were set also for heavier vehicles. In 1996 an environmental zone was created in the central parts of the city. This zone stops traffic with trucks and busses that do not fulfil predetermined demands on age (max 8 years), weight and exhaust emissions. The result has been lowered emissions of particles and nitrogen dioxide, but also decreasing levels of noise. Nevertheless, measurements has showen excedances of the EC limit values for NO_2 on street stations in the city center, why the county recently has worked out a program with suggestions how to further improve the air quality.

Today concentration of air pollution in Gothenburg is almost equal (for some pollutants higher) to the concentrations in the much larger city of Stockholm but lower compared with other major European cities.

Transportation is still the major source of local emissions of air pollution and contributes together with ships and ferries to approximately 70% of emitted particles in Gothenburg. Mechanically generated particles due to wear of roads and possibly also tyres is important, especially for PM_{10} at street level, but affects also the urban background levels of particles. The regional background is mainly determined by secondary particles. The resuspension of road dust is at most during spring.

The topography of Gothenburg with long valleys along Göta älv (a river valley), Mölndalsån and other watercourses makes the area sensitive to inversions.

The local production of ozone is very low and the majority is due to long distance transportation from other parts of Europe.

Exposure data

The monitoring network (http://www.miljo.goteborg.se/luftnet/index-eng.htm) in Gothenburg includes both roof level and street level measurements. In this health impact assessment (and in APHEIS) PM_{10} and ozone data is from the original roof top station *Femman*. Measurements of PM_{10} are performed continuously at two fixed sites in Gothenburg, one rooftop site and one street station, and at a few mobile stations. Ozone is measured at two roof top sites in the city centre of Gothenburg.

The PM_{10} measurements (TEOM) are routinely corrected by a local factor determined to be 1.2.

How indicators used in the HIA have been calculated:

> PM_{10}: daily exposure indicator has been calculated as the mean of the daily concentrations of the station.
>
> Ozone: the daily maximum 1-hour indicator has been calculated as the arithmetic mean of the 1-hour maximum at the station for the whole year. The daily maximum 8-hour moving average of each day have been calculated as the arithmetic mean of the maximum 8-hour moving averages of the station for the summer period (1st April to 30th September).
>
> The annual mean level (SD) of PM_{10} as the urban background concentration in Gothenburg was 21 (10) µg/m^3, and P5 and P95 of the daily mean values were, respectively, 9 µg/m^3 and 39 µg/m^3. The mean (SD) , P5 and P95 of the daily maximum 8-hour moving average concentrations of O_3 were, respectively, 79 (18), 51 and 111 µg/ m^3, and those of the daily maximum 1-hour concentrations 75 (23), 36 and 115 µg/m^3 (Table 1 and figures 1-3)

Table 1. Descriptive statistics for ozone and PM_{10} levels in Gothenburg 2002.

	O3 8h – summer	O3 1h max – year	PM10 – year
Number	183	365	365
Minimum	36	8	5
Percentile 5	51	36	9
Percentile 25	66	59	15
Median	77	76	20
Percentile 75	92	90	26
Percentile 95	111	115	39
Percentile 98	120	126	48
Maximum	126	134	63
Daily mean	79	75	21
standard deviation	18	23	10

Figure 1. Distribution of daily O3 8h max in Gothenburg. Summer 2002

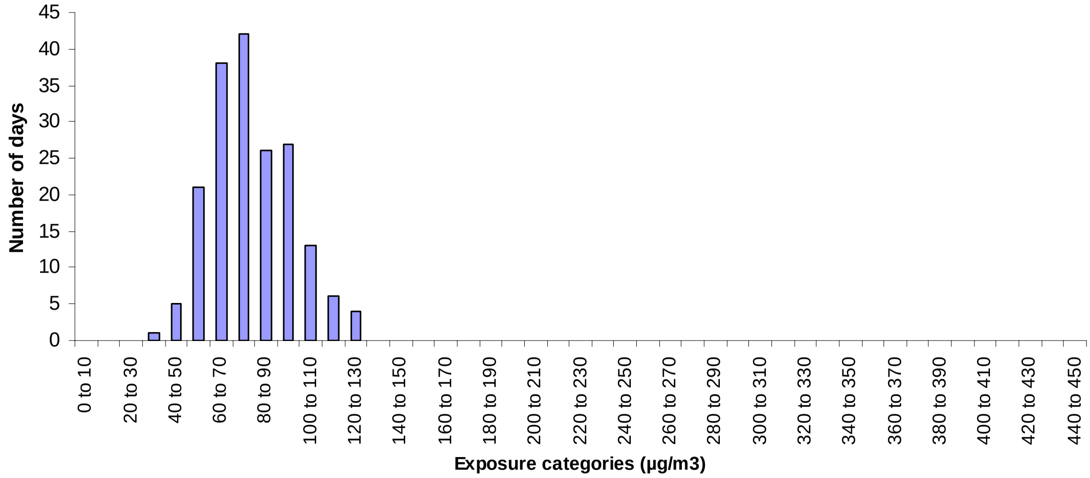


Figure 2. Distribution of daily O3 1h max in Gothenburg. Year 2002

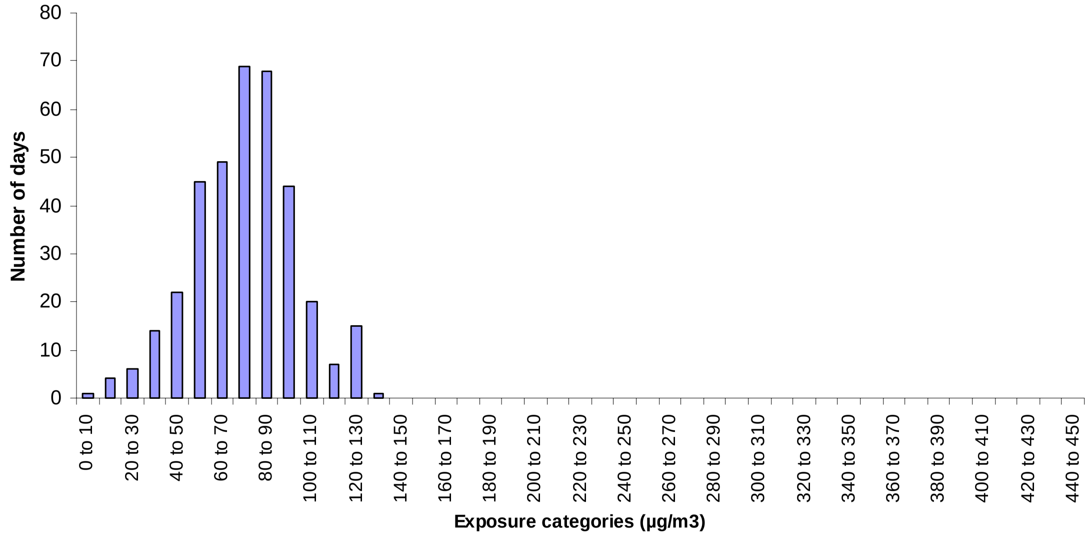
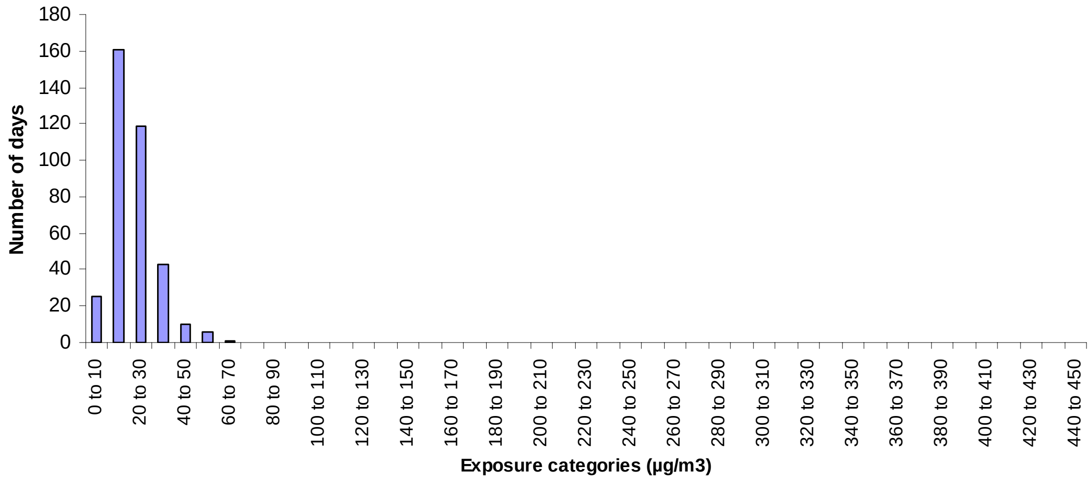


Figure 3. Distribution of daily PM10 levels in Gothenburg. Year 2002



During 2002 the daily max 8h O_3 levels in central Gothenburg exceeded the 2010 limit value for ozone four times. There has been a slightly increasing trend of ozone both in the central parts of Gothenburg and in the outskirts of the city. The trend in the city center is most likely result of decreasing levels of NO_2 and increasing levels of ozone in the regional background.

Health data

The Centre for Epidemiology (EpC) is a part of the Swedish National Board of Health and Welfare (http://www.sos.se/epc/epceng.htm.), and is responsible for national health registers used in this HIA (ENHIS-1 WP5), namely the Cause of Death Registry and the Hospital Discharge Registry.
Statistics Sweden is however entrusted by the EpC with the actual compilation of the mortality statistics. Only 0.8 % of cases are lacking cause of death. Information to the Hospital Discharge Registry is delivered once a year to EpC from each of the 26 county councils in Sweden. The completeness of more than 99% and a low frequency of missing cause (1%) give the register a high quality. Data on hospital emergency visits has only recently been included in the register, and is likely underreported. Frequency data on cough and respiratory symptoms in children is not availible in the register.

Table 2 shows basic health data used in the calculations.

As obvious from the table the death rate in infants is low, with a total postneonatal mortality of 3 deaths during 2002 which gives an annual rate of 51.3 per 100 000. The mean daily number of deaths as total- , cardio-vascular- and respiratory mortality was 12.6, 5.6 and 1.

Table 2. Descriptive statistics for health outcomes in Gothenburg 2002.

Health outcome	ICD9	ICD10	Annual deaths	Annual rate (per 100 000)	Daily mean (SD)	Daily rate (per 100 000)	Annual incidence rate (per 100 000)
POSTNEONATAL MORTALITY							
Total			3	51.3			
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	0	0.0			
Sudden infant death syndrome *ICD9 798.0 – ICD10 R95*	798.0	R95	1	17.1			
GENERAL POPULATION MORTALITY							
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99			12.6 (3.7)	2.7	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99			5.6 (2.4)	1.2	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99			1.0 (1.0)	0.2	
MORBIDITY							
Cough					not available		
Lower respiratory symptoms LRS					not available		
Emergency room visits for asthma - Age < 18 years *ICD9 493, ICD10 J45 J46*	493	J45-J46			0.6	0.7	
Hospital respiratory admissions - Age < 15 years *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99					1003.3
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99					384.3
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99					2799.5

Health Impact Assessment

Methodology

Health impact of air pollution (AP) has been calculated as the annual number of health events attributable to AP in the target population. A causal relationship between AP and the effects is assumed, and therefore HIA can only be performed for those outcomes with sufficient evidence of causality. Once the effects with sufficient evidence of causal relationship with AP have been determined, the next step is to find the best exposure-response functions (ERFs) for each of the selected outcomes. Table 3 shows the result of a systematic review on these issues carried out by the Bilbao Apheis team[1] for WP5 of ENHIS-1. This table summarizes the health outcomes and ERFs deemed suitable for HIA according to the criteria established by WP5 with the advice of the air pollution experts of WP5[2].

Table 3. Health outcomes and Exposure-response functions (ERFs) selected for health impact assessment.

	OUTCOME	POLLUTANT	ERFs	ORIGINAL SOURCE
CHILDREN – PARTICLES				
	Total postneonatal mortality (1 month-1 year)	PM_{10} Annual Mean	RR=1.048 (1.022-1.075) ↑10µg/m^3	Lacasaña et al 2005
	Postneonatal respiratory mortality ICD9 460-519 ICD10 J00-J99	PM_{10} Annual Mean	RR=1.216 (1.102-1.342) ↑10µg/m^3	Lacasaña et al 2005
	Postneonatal Sudden Infant Death Syndrome (SIDS) mortality (normal birth weight ≥2500g) ICD9 798.0 –ICD10 R95	PM_{10} Annual Mean	Adjusted Odds Ratio AOR=1.12 (1.07-1.17) ↑10µg/m^3	Woodruff et al. 1997
	Cough	PM_{10} Daily Mean	OR=1.041 (1.020-1.062) ↑10µg/m^3	Ward & Ayres 2004
	Lower respiratory symptoms LRS	PM_{10} Daily Mean	OR=1.041 (1.020-1.051) ↑10µg/m^3	Ward & Ayres 2004
CHILDREN – OZONE				
	Emergency room visits for asthma <18 Y ICD9 493, ICD10 J45 J46	Ozone Maximum 1 h	RR=1.0116 (1.0067-1.0165) ↑10µg/m^3	CARB 2004
ADULTS/GENERAL POPULATION				
	Total mortality all causes ICD9 <800 ICD10 A00-R99	Ozone Maximum 8 h Summer	RR= 1.0031 (1.0017-1.0052) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)
	Respiratory mortality ICD9 460-519 ICD10 J00-J99	Ozone Maximum 8 h Summer	RR= 1.0113 (1.0074-1.0151) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)
	Cardiovascular mortality ICD9 390-459 ICD10 I00-I99	Ozone Maximum 8 h Summer	RR= 1.0046 (1.0022-1.0073) ↑10µg/m^3	Gryparis et al 2004 (APHEA 2)

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[1] Cambra K, Alonso E, Cirarda FB, Martínez-Rueda T. Bilbao APHEIS group. Selection of outcomes and exposure response functions for health impact assessment of particles and ozone. Review of the evidence. ENHIS project. WORK PACKAGE 5. Bilbao, February 2005. Http:

[2] Ferran Ballester: Valencian School of Health Studies, Valencia, Spain; Sylvie Cassadou: National Institute of Public Health Surveillance, InVS, Toulouse, France; Fintan Hurley: Institute of Occupational Medicine, Edinburgh, Scotland, UK; Nino Künzli: University of Southern California, Division of Occupational and Environmental Health, Los Angeles, CA, USA; Odile Meckel: Institute of Public Health NRW (LOEGD), Bielfeld, Germany; Hans-Guido Mücke: WHO Collaborating Center (Air)-Federal Environmental Agency, Berlin, Germany; Nikolaos Stilianakis: Institute for Environment and Sustainability, European Commission – JRC, Ispra, Italy.

To be coherent with mortality findings, it was decided, with the experts' advice, to include RRs of hospital admissions in the health impact assessment calculations, even if they were not statistically significant. More concretely, it was decided that if there was not any new RR published by the time of making the calculations, the RRs for respiratory hospital admissions from Anderson's meta-analysis could be used, although they were not statistically significant (see Table 2). The rationale for that is that if there is sufficient evidence to accept a causal relationship between air pollution and respiratory mortality -both in children-PM and adults-O_3 we should easily accept that there will also be an impact on hospital admissions.

Table 4. Complementary Exposure-response functions (ERFs) for health impact assesment on respiratory hospital admissions for children (particles) and adults (ozone).

	OUTCOME	POLLUTANT	RR	SOURCE
CHILDREN – PARTICLES				
	Respiratory hospital admissions 0-14 Y ICD9 460-519 ICD10 J00-J99	*PM_{10}* Daily Mean	*RR= 1.010 (0.998-1.021) ↑10µg/m^3*	*Anderson 2004*
ADULTS/GENERAL POPULATION				
	Hospital respiratory admissions 15-64 Y ICD9 460-519 ICD10 J00-J99	*Ozone Maximum 8 h*	*RR=1.001 (0.991-1.012) ↑10µg/m^3*	*Anderson et al 2004*
	Hospital respiratory admissions >64 Y ICD9 460-519 ICD10 J00-J99	*Ozone Maximum 8 h*	*RR=1.005 (0.998-1.012) ↑10µg/m^3*	*Anderson et al 2004*

Finally, HIA needs defining the evaluation scenarios, i.e. the hypothetical scenario with which we want to compare the current air pollution situation. We calculate the impact on health of the (current) air pollution levels in the city that are above the pollution level of the evaluation scenario. In other words, the attributable number of health events (deaths, hospital admissions…) calculated for each scenario represents the number of events that would be prevented if, all other things being equal, air pollution levels were reduced to the evaluation scenario level. These evaluation scenarios are based on the objectives and limits established in 1999/30/CE, and 2002/3/CE Directives.

HIA scenarios

1 - HIA scenarios for PM_{10}

1.1.- Scenarios for HIA on **short-term** effects of PM_{10} and **cough, lower respiratory symptoms** in people under 18 year (<18), and **hospital respiratory admissions** in people under 15 year (< 15)

1.1.1 Reduction of PM_{10} levels to a 24-hour value of **50 µg/m^3** in all days exceeding this value (Limit of 1999/30/CE Directive)

1.1.2. Reduction of PM_{10} levels to a 24-hour value of **20 µg/m^3** in all days exceeding this value

1.1.3 Reduction **by 5 µg/m^3** of all the 24-hour values

1.2.- Scenarios for HIA on **long-term** effects of PM_{10} and **postneonatal mortality** (total, respiratory and sudden infant death syndrome-SIDS)

1.2.1 Reduction of the annual mean value of PM_{10} to a level of **40 µg/m^3** (Limit of 1999/30/CE Directive for 2005)

1.2.2 Reduction of the annual mean value of PM_{10} to a level of **20 µg/m^3** (Limit of 1999/30/CE Directive for 2010)

1.2.3 Reduction **by 5 µg/m^3** of the annual mean value of PM_{10}

2 - HIA scenarios on short-term effects of Ozone

1.2.1 Daily maximum 1-hour concentration and **emergency room visits for asthma** in people under 18 year (< 18)

1.2.1.1 Reduction of O_3 daily maximum 1-hour concentrations to a level of **180 µg/m^3** in all days exceeding this value (Information threshold of 2002/3/CE Directive)

1.2.1.2 Reduction **by 10 µg/m^3** of the daily maximum 1-hour concentrations

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

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

1.2.2.2 Reduction **by 10 µg/m^3** in the daily maximum 8-hour moving average concentrations.

Findings

The annual number of postneonatal deaths attributable to PM_{10} levels higher than 20 µg/m^3 was 0.02 (95% CI: 0.01 – 0.03), which is equivalent to an annual rate of 0.34 deaths per 100 000 (95% CI: 0.17-0.51).

Table 5. Potential benefits of reducing PM_{10} levels. Absolute numbers and rates (per 100 000 children) (95% confidence limits) attributable to the health effects of PM_{10}.

	PM10 reduction	Number of attributable cases per year	Annual rates (per 100.000)
POSTNEONATAL MORTALITY	**Annual mean levels**		
Total	by 5 µg/m^3	0,07 (0,03-0,11)	1.20 (0.51-1.88)
	to 20 µg/m^3	0,02 (0,01-0,03)	0.34 (0.17-0.51)
	to 40 µg/m^3	0,0 (0,0-0,0)	0.0 (0.0-0.0)
Respiratory	by 5 µg/m^3	0,0 (0,0-0,0)	0.0 (0.0-0.0)
	to 20 µg/m^3	0,0 (0,0-0,0)	0.0 (0.0-0.0)
	to 40 µg/m^3	0,0 (0,0-0,0)	0.0 (0.0-0.0)
SIDS	by 5 µg/m^3	0.06 (0.04-0.08)	1.03 (0.68-1.37)
	to 20 µg/m^3	0.02 (0.01-0.02)	0.34 (0.17-0.34)
	to 40 µg/m^3	0,0 (0,0-0,0)	0.0 (0.0-0.0)
MORBIDITY	**Daily levels**		
Cough <18 y	by 5 µg/m^3	Not available	Not available
	to 20 µg/m^3		
	to 50 µg/m^3		
LRS <18 y	by 5 µg/m^3	Not available	Not available
	to 20 µg/m^3		
	to 50 µg/m^3		
Hospital respiratory admissions <15 y	by 5 µg/m^3	3.82 (-0.77-8.00)	4.94 (-1.00-10.34)
	to 20 µg/m^3	1.83 (-0.37-3.86)	2.37 (-0.48-5.00)
	to 50 µg/m^3	0.01 (0.00-0.01)	0.01 (0.00-0.01)

Regarding short-term effects of O_3, each reduction by 10 µg/m^3 of daily maximum 8-hour moving average concentrations would delay 7.0 (95% CI: 3.8 – 11.7) deaths per year in the study area, 4.58 (95% CI: 2.2 – 7.3) from cardiovascular diseases, and 1.85 (95% CI: 1.2 – 2.5) from respiratory causes.

Table 6. Potential benefits of reducing ozone daily levels. Absolute numbers and rates (per 100 000 inhabitants) (95% confidence limits) attributable to the health effects of ozone.

	OZONE reduction	**Number of attributable cases per year**	**Annual rates (per 100.000)**
MORTALITY	**Daily 8-h max**		
Total excluding external causes	by 10 μg/m^3	6.99 (3.83-11.72)	1.47 (0.81-2.47)
	to 120 μg/m^3	0.05 (0.03-0.09)	0.01 (0.01-0.02)
Cardiovascular	by 10 μg/m^3	4.58 (2.19-7.27)	0.96 (0.46-1.53)
	to 120 μg/m^3	0.03 (0.02-0.05)	0.01 (0.01-0.01)
Respiratory	by 10 μg/m^3	1.85 (1.21-2.47)	0.39 (0.25-0.52)
	to 120 μg/m^3	0.01 (0.01-0.02)	0.01 (0.01-0.001)
MORBIDITY	**Daily 1-h max**		
Emergency room visits for asthma <18 y	by 10 μg/m^3	2.48 (1.44-3.53)	2.57 (1.49-3.65)
	to 180 μg/m^3	.0.0 (0.0-0.0)	0.0 (0.0-0.0)
	Daily 8-h max		
Hospital respiratory admissions 15-64 y	by 10 μg/m^3	0.62 (-5.58- 7.45)	0.19 (-1.72-2.30)
	to 120 μg/m^3	0.00 (-0.04-0.05)	0.00 (-0.01-0.015)
Hospital respiratory admissions > 64 y	by 10 μg/m^3	4.97 (-1.99-11.94)	6.78 (-2.71-16.2)
	to 120 μg/m^3	0.04 (-0.01-0.09)	0.05 (-0.01-0.12)

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

Discussion

Only one urban background monitoring station for PM_{10} is used to estimate the exposure for Gothenburg in this study. The same station has been used in epidemiological time series analyses, in which daily numbers of respiratory admissions were associated with PM_{10} and ozone. Since there are no important point sources, the above roof level is not expected to vary much across the city.

During the past 30 years there has been a marked improvement of the air in Gothenburg. The quantities of particles (black smoke), sulphur dioxide, carbon monoxide and lead have declined sharply, as a result of district heating, less industry emissions and cleaner vehicles.

However, a reduction of annual PM_{10} levels by 5 $\mu g/m^3$ would still lead to a decrease in the number of respiratory hospital admissions among children below 15 years of age with approximately 4 visits per year, and avoid one case of postneonatal death in every 10 years. The result of reduced particle levels on these outcomes are not as quantitatively dramatic as the effect seen on the total short and long term mortality, but the effects are still notable. Developments indicate that we can expect further reduction in emissions in the future as a result of cleaner vehicles. Nevertheless, the reduction of coarse fraction of particles in this part of Europe is more uncertain.

This HIA showes that a reduction of the daily 8-hour max summer levels of ozon with 10 $\mu g/m^3$ would decreas the total number of preterm deaths with 1.5 per 100 000 inhabitants. Further it would prevent 2.5 emergency room visits for astma per year among those younger then 18 years, and 5 hospital respiratory admissions among those above 64 years. Most of the ozone effects would still remain also after such a reduction, even in winter. The ozone levels seen i Gothenburg is mainly due to long distance transport from other parts of Europe. The locall production of ozone is only margin and has been estimated to approximately 3 $\mu g/m^3$ under normal circumstances.

Improvements that have been made to lower levels of air pollution in the cities can have the opposite effect on the levels of ozon, especially when lowering the levels of NO. The trend in Gothenburg show increasing levels of ozon both in the city and in the outskirts, which could be explained by decreasing levels of NO in the city center and higher background levels of ozone.

Consequently, in this part of Europe with very low net production of ozone the work within EU is of great importance for lowering current levels.

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