HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

ENHIS-1 PROJECT: WP5 HEALTH IMPACT ASSESSMENT

LOCAL CITY REPORT

Dublin

Summary of main findings for Dublin

In 2002 the PM_{10} annual mean (SD) was 24 (13) µg/m^3, which is slightly above the 1999/30/EC Directive limit value for 2010 (20 µg/m^3), and below that established for 2005 (40 µg/m^3). For the summer period of the same year, the mean (SD), P5 (5th percentile) and P95 of the maximum daily 8-hour moving average concentration of ozone (O_3) were 60(15), 38 and 83 µg/m^3.

As far as short-term effects of O_3 in summer are concerned, all other things being equal, each reduction by 10 µg/m^3 of the daily maximum 8-hour moving average concentrations would delay 6 deaths per year in the general population in the study area, 3 from cardiovascular diseases, and 3 from respiratory causes. In terms of hospital admissions, this would represent 10.2 respiratory admissions in the adult population and 8.7 in the population over 64 years.

Summary of HIA of outdoor air pollution in Dublin 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)					1.0031 (1.0017-1.0052)		6.18	
Cardiovascular mortality (ICD9 390-459 - ICD10 I00-I99)	All ages	O_3 8h max	Summer[2]	Daily	1.0046 (1.0022-0.0073)	Gryparis et al 2004	3.73	
Respiratory mortality (ICD9 460-519 - ICD10 J00-J99)					1.0113 (1.0074-1.0151)		3.51	
Total postneonatal mortality					1.048 (1.022-1.075)	Lacasaña et al 2005		xxxxxxxx
Postneonatal respiratory mortality (ICD9 460-519 - ICD10 J00-J99)	1 month-1 year	Corrected PM_{10}[3]	Year	Annual	1.216 (1.102-1.342)			xxxxxxxx
Postneonatal Sudden Infant Death Syndrome Mortality (ICD9 798.0 - ICD10 R95)					1.12 (1.07-1.17)	Woodruff 1997		xxxxxxxx
Morbidity								
Emergency room visits for asthma (ICD-9 codes 493, ICD-10 codes J45, J46)	< 18 years	O_3 1h max			Not available	CARB 2004	Not available	
Cough	< 18 years	Measured PM_{10}	Year		Not available	Ward and Ayres 2004		not available
Lower respiratory symptoms LRS	< 18 years	Measured PM_{10}		Daily	Not available	Ward and Ayres 2004	Not available	xxxxxxxx
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	< 15 years	Measured PM_{10}			1.010 (0.998-1.021)			xxxxxxxx
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	15 - 64 years	**O_3 8h max**	Summer		1.001 (0.991-1.012)	Anderson et al 2004	1.56	
Hospital respiratory admissions (ICD9 460-519 - ICD10 J00-J99)	> 64 years				1.005 (0.998-1.012)		8.69	

[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

This report is based on data for Dublin, the capital city of Ireland for the year 2002. Dublin is situated on the east coast of Ireland. Due to the climatic conditions experienced in Ireland, the conditions favorable to pollution formation do not occur too often. Generally the weather conditions are such that about 3 to 4 weather systems cross the country each week during winter. It is only when a high-pressure center is located near or over the country that pollution levels are likely to raise.

In previous health impact assessments for Dublin (APHEIS 2) for the year 2000 we concentrated on looking at particulate pollution levels, and the data was based on Black Smoke (BS) measurements of particulate levels. Since then the PM10 network has developed and the data presented in this report is based on the PM10 data.

The daily mean values of PM10 as reported here for 2002 are significantly higher than the BS measurements as used in APHEIS 2, although at an average of 24? gm^{-3}, this is still a comparatively low level. This can be attributed to the fact that BS and PM10 do not quite measure the same size fractions, with BS measuring particles up to about PM4.5. In addition the BS measurement is based on the "blackness" of the particles, not the mass, and it therefore more source dependent.

In addition to including PM10 in this particular study, we also report Ozone (O3) data for Dublin for the first time as part of a health impact assessment related to air pollution exposure.

Ireland has in general high respiratory and cardiovascular mortality and morbidity rates compared to most of the rest of Europe (APHEA 2), and therefore exposure to air pollution is of particular interest.

During the 1980s Dublin experienced severe pollution events, the situation became so severe that an intervention was required. Domestic heating, namely the burning of coal in open grates was identified at the time as the major source of air pollution. Following the intervention, which almost overnight stopped coal burning, particulate pollution levels dropped significantly, and this drop was maintained. An improvement in health was also observed (Clancy et al 2002).

Since the mid 1990s the Dublin economy has been growing very rapidly, but the infrastructure has struggled to keep up with the rest of the development. Dublin does not have a metro system, and is virtually dependent on road transport, with severe traffic blockages a common occurrence.

Road traffic is now considered to be the major contributor to particulate pollution levels in Dublin (85%).

With the high levels of respiratory and cardiovascular mortality and morbidity, this report focuses on the at risk groups within the population, namely the very young, and the elderly.

The mortality data used in this study is based on the national mortality files as supplied by the Central Statistics office. The morbidity data relating to emergency hospital admissions is supplied by the economic social research institute. Comprehensive data relating to emergency room visits is not routinely collected, and therefore is not included as part of this report.

In previous work (APHEIS 2), due to the relatively clean air in Dublin, the health benefit associated with further reductions in air pollution levels were seen to be quite small, a similar observation is seen in this current report.

This work has been carried out within the framework of work package WP5 on health impact assessment of ENHIS-1 project (www.enhis.net).

Sources of air pollution

As previous mentioned, motor vehicles are viewed as the main contributor to particulate pollution levels in Dublin city (85%) with heating systems (7%), industry (7%) and others 1%. Any initiative to reduce pollution levels needs to address the traffic volumes transiting through the city, be that by introducing alternative public transport systems such as a metro, or by reducing traffic congestion and allowing the traffic to flow more freely. In reality a combination of many items is probably what will happen in the short term, as a metro system will take many years to develop. 2004 saw the introduction of a limited light rail system, but it will take time to see if this has had any impact on the pollution levels.

Exposure data

The air pollution data, PM10 was measured at a number of sites which form part of the Dublin City Council monitoring network. Data was available for all but one day of the year. The PM10 measurements were made using a gravimetric system.

The Ozone data was measured at one site in the south inner city, at a monitoring station operated by the Irish EPA. Data from this site was available for 361 days of the year. Source of the AP data, number of monitoring stations for particles and ozone, analytical methods, correction factor used to compensated losses of volatile compounds (if used)

How indicators have been calculated:

PM10: daily exposure indicator has been calculated as the arithmetic mean of the daily concentrations of the stations.

Ozone: The daily maximum 1-hour concentration and the daily maximum 8-hour moving averages of each day have been calculated for the summer period (1st April to 30th September).

AP data description: The annual mean level (SD) of PM10 in Dublin was 24 13) µg/m3, and P5 and P95 of the daily mean values were, respectively, 12 µg/m3 and 50 µg/m3. The summer mean (SD), P5 and P95 of the daily maximum 8-hour moving average concentrations of O3 were, respectively, 60 (15), 38 and 83 µg/ m3, and those of the daily maximum 1-hour concentrations 65(16), 38 and 87 µg/m3 (Table 1 and figures 1-3). The data for these are presented in table 1 and in figures 1 to 3.

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

	O3 8h - summer	O3 1h max - year	PM10 - year
Number	183	361	364
Minimum	22	10	6
Percentile 5	38	38	12
Percentile 25	49	56	16
Median	59	66	21
Percentile 75	71	76	29
Percentile 95	83	87	50
Percentile 98	88	96	59
Maximum	106	120	92
Daily mean	60	65	24
standard error	15	16	13
% missing values	0.00	1	0.27

Figure 1 Dublin Ozone (O3) 8h max - summer 2003

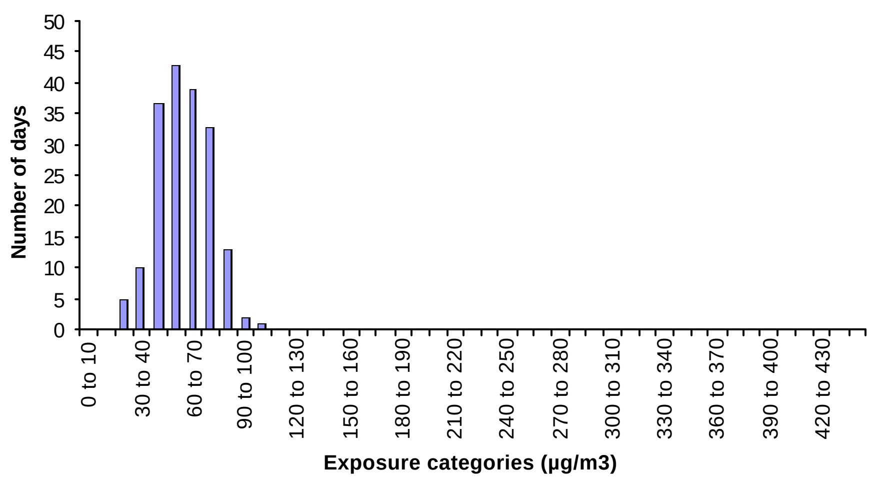


Figure 2 Dublin Ozone (O3) 1h max - year 2002

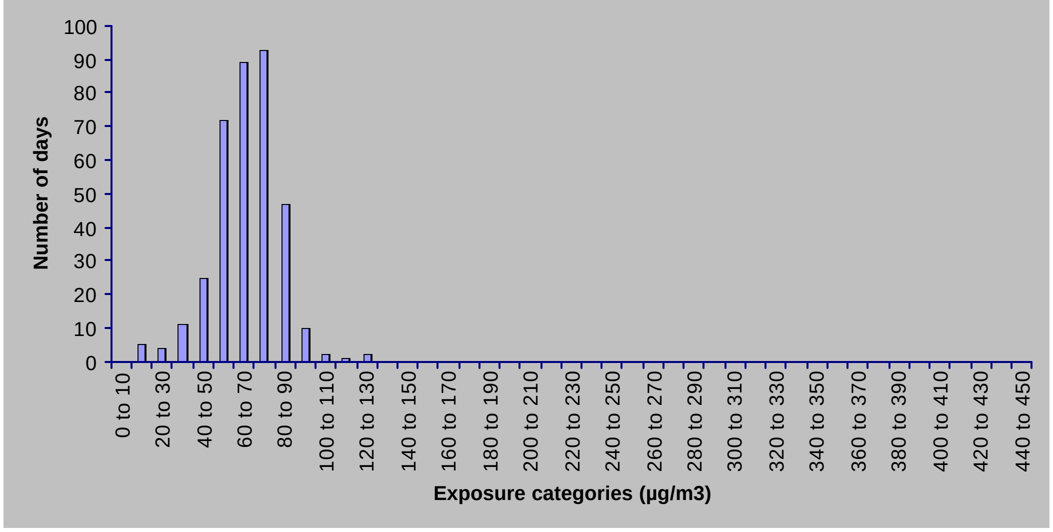
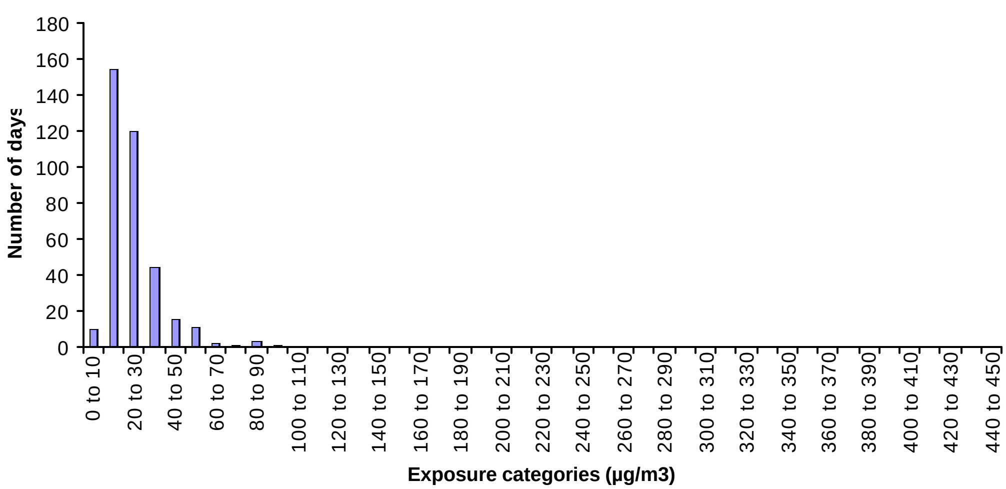


Figure 3 Dublin PM 10 - year 2002



Health data

As mentioned previously, the mortality data for Dublin is extracted from the national register of mortality, which is provided by the central statistics office. This data is complete, and is provided for daily values. This data is supplied for research under the stringent conditions. Emergency hospital admission data is provided by the Economic and social research Institute, and is 99% complete for 2002. This data subject to quality control. Like the mortality data stringent conditions apply to the use of the data for research. The support of both the Central Statistics Office (CSO) and the Economic and Social Research Institute (ESRI) is acknowledged.

Emergency GP or hospital visits are not routinely collected, and so this data is not used in this study.

Table 2. Descriptive statistics for health outcomes in Dublin for 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			15	269.6	0.041	0.74	
Respiratory *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	0	0	0	0	
Sudden infant death syndrome *ICD9 798.0 – ICD10 R95*	798.0	R95	5	89.9	0.014	0.25	
GENERAL POPULATION MORTALITY							
Total mortality all causes *ICD9 <800 ICD10 A00-R99*	<800	A00-R99	4140	835	11.342 (3.63)	2.288	
Cardiovascular mortality *ICD9 390-459 ICD10 I00-I99*	390-459	I00-I99	1656	334	4.537(2.23)	.915	
Respiratory mortality *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	655	132	1.792 (1.43)	.361	
MORBIDITY			**Annual**	**Annual rate (per 100 000**	**Daily mean (SD)**	**Daily rate (per 100 000**	**Annual incidence rate (per 100 000)**
Cough			not available		not available		
Lower respiratory symptoms LRS			not availabl e		not available		
Emergency room visits for asthma - Age < 18 years *ICD9 493, ICD10 J45 J46*	493	J45-J46	not available		not available		
Hospital respiratory admissions - Age < 15 years *ICD9 460-519 ICD10 J00-J99*	460-519	J00-J99	1068	1332	2.93	3.65	
Hospital respiratory admissions - Age 15 -64 years	460-519	J00-J99	1669	474	4.57	1.3	
Hospital respiratory admissions - Age > 64 years	460-519	J00-J99	2548	4015	6.98	11	

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 team1 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	Not available	Ward & Ayres 2004
	Lower respiratory symptoms LRS	PM_{10} Daily Mean	Not available	Ward & Ayres 2004
CHILDREN – OZONE				
	Emergency room visits for asthma <18 Y ICD9 493, ICD10 J45 J46	Ozone Maximum 1 h	Not available	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-O3- we should easily accept that there would also be an impact on hospital admissions.

Table 4. Complementary Exposure-response functions (ERFs) for health impact assessment 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/m³*	*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/m³*	*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/m³*	*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), this scenario is not available for Dublin, due to lack of dat relating to this specific health outcome), 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). The 95% in Dublin is at **50 µg/m ^{3}**, and so this s cenario will have negligible effect.

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/m³** (Limit of 1999/30/CE Directive for 2005). Dublin is already achieving this objective.

1.2.2 Reduction of the annual mean value of PM_{10} to a level of **20 µg/m³** (Limit of 1999/30/CE Directive for 2010), Dublin is already very close to this objective, based on the 2002 PM10 data.

1.2.3 Reduction **by 5 µg/m³** of the annual mean value of PM_{10}

2. HIA scenarios on short-term effects of Ozone

1.2.1 Daily maximum 1-hour concentration and **emergency room visits for asthma** in people under 18 year (< 18). This health outcome data is not available for Dublin, and therefore is not included in the analysis.

1.2.1.1 Reduction of O_3 daily maximum 1-hour concentrations to a level of **180 µg/m³** in all days exceeding this value (Information threshold of 2002/3/CE Directive) This value was not exceeded in Dublin, and therefore this scenario is not considered.

1.2.1.2 Reduction **by 10 µg/m³** of the daily maximum 1-hour concentrations

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

1.2.2.1 Reduction of O_3 daily maximum 8-hour moving average concentrations to **120 µg/m³** in all days exceeding this value (Limit for health protection of 2002/3/CE Directive)

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

Findings

The annual number of postneonatal deaths attributable to PM_{10} levels higher than 20 ? g/m³ was 0.5 (95%CI: 0.23 0.83).

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/m³	0,12 (0,05-0,18)	0.02 (0.01-0.03)
	to 20 µg/m³	0,52 (0,23-0,83)	0.07 (0.03-0.12)
	to 40 µg/m³	0,08 (0,04-0,12)	0.01 (0.01-0.02)
Respiratory	by 5 µg/m³	not available	not available
	to 20 µg/m³	-	-
	to 40 µg/m³	-	-
SIDS	by 5 µg/m³	-	-
	to 20 µg/m³	-	-
	to 40 µg/m³	-	-
MORBIDITY	**Daily levels**		
Cough <18 y	by 5 µg/m³	not available	not available
	to 20 µg/m³	not available	not available
	to 50 µg/m³	not available	not available
LRS <18 y	by 5 µg/m³	not available	not available
	to 20 µg/m³	not available	not available
	to 50 µg/m³	not available	not available
Hospital respiratory admissions <15 y	by 5 µg/m³		
	to 20 µg/m³		
	to 50 µg/m³		

Regarding short-term effects of O_3, each reduction by 10 µg/m^3 of daily maximum 8 hour moving average concentrations would delay 6.18 (95%CI: 3.39 10.17) deaths per year in the study area, 3.73 (95%CI: 1.79 –5.92) from cardiovascular diseases, and 3.50 (95%CI: 2.30 – 4.69) 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	by 10 µg/m^3	8,99 (4,93- 15,08)	1,27 (0,70-2,13)
	to 120 µg/m^3	NA	NA
Cardiovascular	by 10 µg/m^3	4,29 (2,05- 6,81)	0,61 (0,29-0,96)
	to 120 µg/m^3	NA	NA
Respiratory	by 10 µg/m^3	3,55 (2,32- 4,74)	0,50 (0,33-0,67)
	to 120 µg/m^3	NA	NA
MORBIDITY	**Daily 1-h max**		
Emergency room visits for asthma <18 y	by 10 µg/m^3	not available	not available
	to 180 µg/m^3	…..	
	Daily 8-h max		
Hospital respiratory admissions 15-64 y	by 10 µg/m^3	0.998(1.01-1.021)	
	to 120 µg/m^3	NA	
Hospital respiratory admissions > 64 y	by 10 µg/m^3	8.69 (-3.48-20.87)	
	to 120 µg/m^3	NA	

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

Discussion

This Health Impact assessment has shown that reducing PM10 levels and Ozone levels can lead to a small reduction in mortality/morbidity levels in Dublin, however the current levels of these pollutants in Dublin is very small and is currently close to the levels proposed by the directive for 2010.

Dublin previously experienced extreme pollution levels, however following a very successful intervention (Clancy et al 2002), the pollution levels fell dramatically, and resulted in a significant reduction in mortality. Clearly it is hoped that with further reductions in pollutants that more reductions in mortality and morbidity can be achieved, however the current pollution levels in Dublin are such that any decrease will only bring about extremely small changes in mortality or morbidity which will be very difficult to quantify.

The challenges facing Dublin are to control the PM10 emissions, as the booming economy is giving rise to ever increasing road traffic levels. Reducing emissions from road traffic will be the big test, clearly introducing a metro system could in some way go towards achieving this aim, but the time frame for such a system will take many years.

This HIA has focussed on ambient pollution levels, but as people spend more time indoors, we perhaps need to focus on indoor pollution levels as well, and specifically in locations where tobacco is consumed. In 2004 Ireland introduced a smoke free work environment, and there are ongoing studies to quantify the benefits of that particular intervention. (Agnew et al, McCaffrey et al ERS Copenhagen Sept 2005).

Conclusion

Pollution levels from both PM10 and Ozone in Dublin are at the lower ends of the spectrum, and are already approaching the guide values set for 2010. As with all other centres reducing pollution levels should lead to reductions in mortality and morbidity, the reductions as determined in this study will be very small.

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