Environment International 41 (2012) 1–7

Contents lists available at SciVerse ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Health effects for the population living near a cement plant: An epidemiological assessment

Martina Bertoldi [a,*], Alessandro Borgini [a], Andrea Tittarelli [a], Elena Fattore [b], Alessandro Cau [a], Roberto Fanelli [b], Paolo Crosignani [a]

[a] *Environmental Epidemiology and Cancer Registry Unit, National Cancer Institute, Via G. Venezian 1, 20133 Milano, Italy*
[b] *Department of Environmental Health Sciences, Mario Negri Institute for Pharmacological Research, Via G. La Masa 19, 20154 Milano, Italy*

ARTICLE INFO

Article history:
Received 20 January 2011
Accepted 23 December 2011
Available online xxxx

Keywords:
Cement plant
Health effects
Air pollution
Nitrogen oxides
GIS

ABSTRACT

Epidemiological studies have shown the association between the exposure to air pollution and several adverse health effects. To evaluate the possible acute health effects of air pollution due to the emissions of a cement plant in two small municipalities in Italy (Mazzano and Rezzato), a case–control study design was used. The risks of hospital admission for cardiovascular or respiratory diseases for increasing levels of exposure to cement plant emissions were estimated, separately for adults (age > 34 years) and children (0–14 years). Odds ratios (OR) were estimated using unconditional regression models. Attributable risks were also calculated.

Statistically significant risks were found mainly for respiratory diseases among children: OR 1.67 (95% CI 1.08–2.58) for the moderately exposed category (E1), OR 1.88 (95% CI 1.19–2.97) for the highly exposed category (E2), with an attributable risk of 38% of hospital admissions due to the exposure to cement plant exhausts. Adults had a weaker risk: OR 1.38 (95% CI 1.18–1.61) for group E1, OR 1.31 (95% CI 1.10–1.56) for group E2; the attributable risk was 23%. Risks were higher for females and for the age group 35–64. These results showed an association between the exposure to plant emissions and the risk of hospital admission for cardiovascular or respiratory causes; this association was particularly strong for children.

1. Introduction

A cement plant can be an important source of air pollutants. Few studies have focused on the health effects attributable to the emissions of a cement plant on the population living in the proximity (Rovira et al., 2010; Schuhmacher et al., 2004), some of them investigating different outcomes, such as respiratory symptoms (Legator et al., 1998), preterm delivery (Yang et al., 2003) or psychasthenia (Brockhaus et al., 1981). Occupational studies have focused only on cement plant workers (Al-Neaimi et al., 2001; Alvear-Galindo et al., 1999) and other studies analysed the chemicals in soil (Asubiojo et al., 1991; Schuhmacher et al., 2002) or their impact on air quality (Kabir and Madugu, 2010).

The local authorities of two small municipalities (Mazzano and Rezzato, Brescia province, Lombardy region, Northern Italy) asked the authors of this paper to evaluate the health impact on people living in the area surrounding a cement plant. The area is highly industrialized and densely populated and local authorities are more and more involved in decisions whose fallout can have consequences on population health conditions.

We carried out a risk assessment of the acute health effects due to the emissions of the cement plant on the population of the two municipalities adopting a case–control study design. The evaluation of the health effects was carried out choosing nitrogen oxides (NO_x) as a proxy for cement plant emissions (Canpolat et al., 2002; Ekinci et al., 1998).

We used a Geographic Information System (GIS) to attribute the exposure to air pollution for all the subjects analysed. As health outcomes we considered all hospital admissions for respiratory or cardiovascular causes for residents in the two municipalities.

2. Materials and methods

2.1. Study base

The population considered included all the residents of the municipalities of Mazzano and Rezzato in the years between 2002 and 2005, inclusive: 22,721 people per year on average, 9997 resident in Mazzano and 12,724 in Rezzato (Italian National Statistical Institute, ISTAT data on 31 December 2003).

As cases, we considered all hospital admissions of Mazzano or Rezzato residents between January 1st 2002 and December 31st, 2005. These data were provided by the Brescia Local Health Unit (ASL). The hospital admissions of interest for this study were selected

* Corresponding author. Tel.: +39 02 23903540; fax: +39 02 23902762.
E-mail address: martina.bertoldi@istitutotumori.mi.it (M. Bertoldi).

0160-4120/$ – see front matter
doi:10.1016/j.envint.2011.12.005

using the ICD-IX code of the principal diagnosis of discharge. Diagnoses of interest were chosen on the basis of evidence in the literature indicating a significant association between exposure to air pollutants and some acute cardiovascular (Ballester et al., 2001; Poloniecki et al., 1997) and respiratory diseases (Prescott et al., 1998; Wong et al., 1999). People from 15 to 34 years were excluded from the analysis because of the small number of hospital admissions. Tables 1 and 2 list the diagnostic codes considered for adults (age from 35 years on) and for children (younger up to 14 years).

The unit of observation considered was the single hospital admission, not the person: all admissions were taken as single cases even if referring to the same patient. Thus some subjects will have been counted as cases more than once, if they had multiple admissions.

Controls were randomly sampled from the total population of the two municipalities, extracted from the Lombardy Region Health Service archives, excluding all the subjects already included as cases, proportioning without individual matching for sex and age. For age classes with more hospital admissions (65 years and over) two controls were extracted for each case, while for age classes with fewer hospital admissions (children and adults between 35 and 64 years) four controls were taken for each case, to boost the power of the statistical analysis.

The same methods were applied to trauma and injuries (3-digit ICD-IX codes from 800 to 959, considering the principal diagnosis of discharge), a group of pathologies potentially not related with air pollution.

2.2. Air pollution data

Air concentrations of cement plant emissions were estimated by Consulenze Ambientali s.p.a (http://www.comunerezzato.it/comrez/bin/files/indaginearia.pdf), both by modelling emissions and by direct measuring. Pollutants were measured using mobile stations placed in four different areas (two in each municipality) during two 20-day campaigns, one in summer (September 2006) and one in winter (January 2007).

In this study we focused on NO_x, because the comparison between cement plant emissions modelling and direct measures showed that the contribution of the cement plant was particularly significant for NO_x.

2.3. Geocoding

The address of residence (municipality, street and number) of all the subjects included in the study was retrieved through the Lombardy Region Health Service archives.

Table 1
Diseases considered (adults, age > 34 years).

Groups	ICD-IX codes	Description
Cardiovascular	410–414	Ischemic heart disease
	415–416	Diseases of pulmonary circulation
	426	Conduction disorders
	427	Cardiac dysrhythmias
	428	Heart failure
	429	Other heart diseases
	444	Arterial embolism and thrombosis
	785	Symptoms involving cardiovascular system
Respiratory	478	Other diseases of upper respiratory tract
	480–487	Pneumonia and influenza
	490–496	Chronic obstructive pulmonary disease and allied conditions
	510	Empyema
	511	Pleurisy
	518	Other diseases of lung
	786	Symptoms involving respiratory system

Table 2
Diseases considered (children, age 0–14 years).

Groups	ICD-IX codes	Description
Respiratory	460	Acute nasopharyngitis
	461	Acute sinusitis
	462	Acute pharyngitis
	463	Acute tonsillitis
	464	Acute laryngitis and tracheitis
	465	Acute upper respiratory infections
	466	Acute bronchitis and bronchiolitis
	472	Chronic pharyngitis and nasopharyngitis
	473	Chronic sinusitis
	474	Chronic disease of tonsils and adenoids
	475	Peritonsillar abscess
	476	Chronic laryngitis and laryngotracheitis
	477	Allergic rhinitis
	478	Other diseases of upper respiratory tract
	490–496	Chronic obstructive pulmonary disease and allied conditions

From the addresses we obtained the geographical coordinates (latitude and longitude) for almost all the subjects.

Then, using the ArcGis 9.2 software package, we created a layer displaying the geographical distribution of subjects (cases and controls).

2.4. Estimated exposure

To estimate the average exposure to NO_x for each person we used the iso-concentration maps of the pollutants for the winter measurement campaign. NO_x distribution in the considered area was over a wider range during the winter (from 81 μg/m^3 to 207 μg/m^3). Although winter concentrations are not representative of annual average concentrations because they are generally higher, the exposure distribution may give a picture of individual exposure differences for the whole year.

In the study area there were no "security zones" where exposure was low, the minimum winter NO_x concentration being 81 μg/m^3. However, it was possible to distinguish areas with higher levels of exposure and areas with lower levels. The health risk estimates were based on these differences. Fig. 1 shows a map of the iso-concentrations of NO_x in the winter campaign.

Using the ArcGis desktop software we created a two layer map in which we displayed NO_x concentrations and subjects (cases and controls). Using the spatial join technique we assigned an exposure value for each subject depending on the location. The subjects were then divided into three groups (less exposed as reference category, moderately exposed, highly exposed). Exposure categories were chosen considering the distribution of the contaminant in the entire area and to provide a narrow reference category. Thus the reference category had a low median value.

The three groups, according to the estimated exposure to NO_x, were as follows:

Less exposed (E_0)	81–110 μg/m^3
Moderately exposed (E_1)	111–150 μg/m^3
Highly exposed (E_2)	> 150 μg/m^3

Fig. 2 shows the division of the area for these groups. The zone with the highest concentration of NO_x is in the neighbourhood of the cement plant.

2.5. Statistics

Odds ratios were calculated applying an unconditional logistic regression model, considering the case–control status as dichotomised dependent variable, and the level of NO_x exposure (E_0, E_1, E_2) as independent variable. Sex and age group were used as adjusting variables.

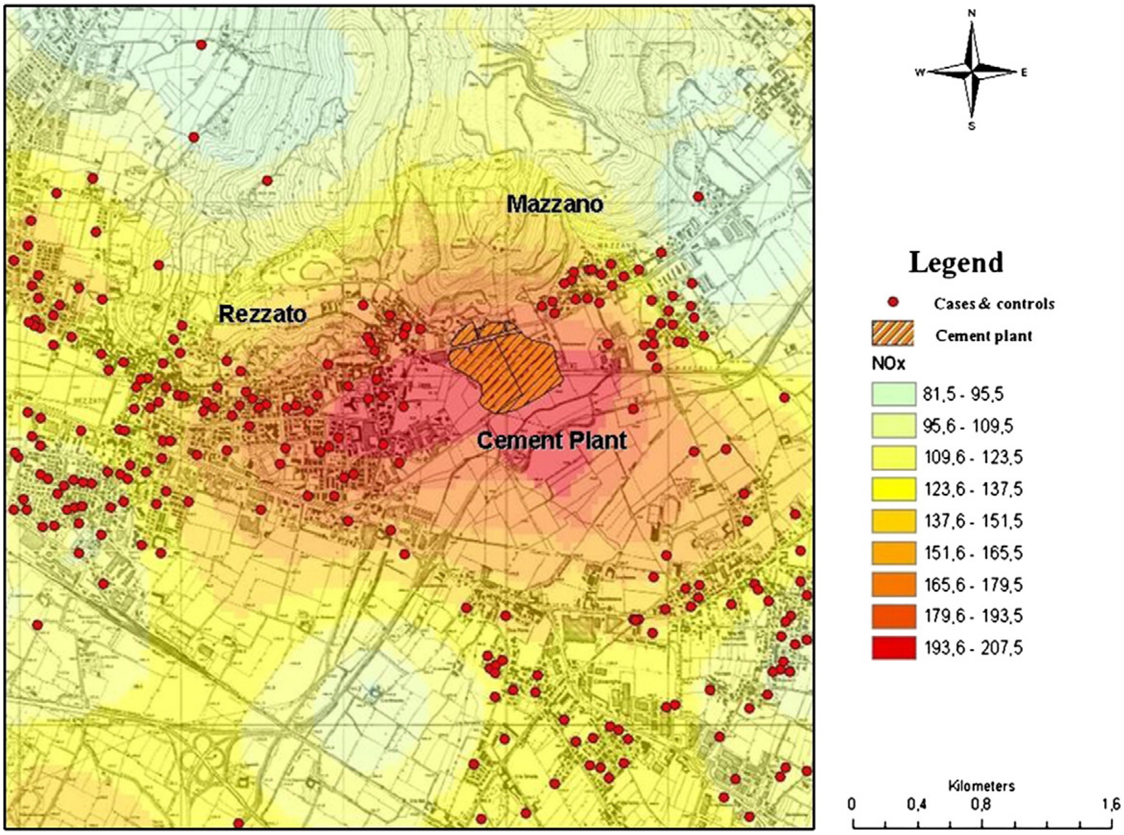

Fig. 1. NO_x iso-concentration map (winter campaign).

Analyses were also conducted by different subgroups, i.e. by sex, age group and group of pathologies (this last only for adults). *p* for trend was calculated considering exposure as a continuous variable.

Attributable risks were also calculated to supply an indicator of the impact of exposure on the population's health (Breslow and Day, 1980).

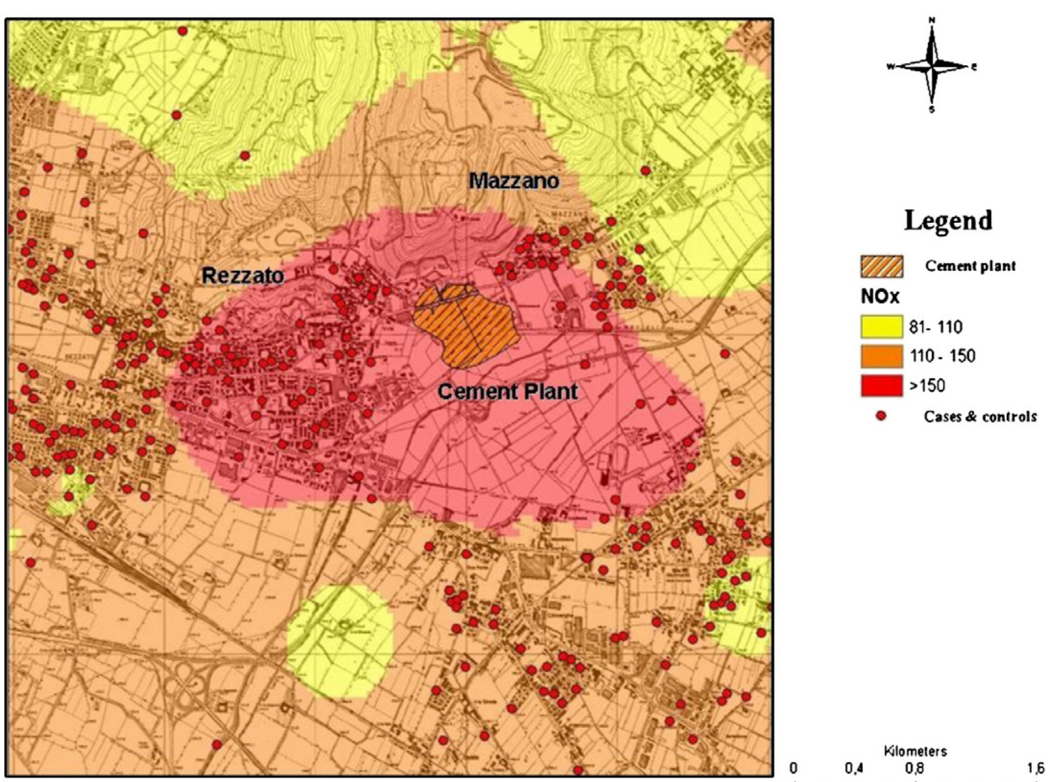

Fig. 2. Division of the area into three levels of NO_x exposure.

Statistical analyses were done using the package Stata SE, version 8.2.

3. Results

Hospital admissions selected were 2209 for adults (1623 for cardiovascular causes, 586 for respiratory causes) and 277 for children (only respiratory diseases). Controls totalled 4081 adults and 1108 children. Cases and controls together totalled 7675 subjects, 6290 adults and 1385 children.

Only a small number (55 out of 7675, 0.72%) were excluded from the analysis, because we could not obtain their precise geographical coordinates. The analysis considered all geocoded subjects (7620), for whom it was possible to estimate the exposure to NO_x, separately for the children (1372 total, 274 cases and 1098 controls) and adults (6248 total, 2182 cases and 4066 controls).

3.1. Adults

Table 3 reports the analysis on the adults, considered overall and then stratifying for sex and the two age groups: younger adults (from 35 to 64 years) and older people (over 65). The overall analysis showed a significant risk for the subjects in the two categories most exposed compared to those less exposed (E0): the probability of hospital admission was about 30% higher for both these categories, though the risk was a little higher for the moderately exposed (E1) than the highest exposed (E2). This figure slightly decreased when adjusting for sex and age group, and the risk for E2 group lost statistical significance. The attributable risk of 23% indicated that 501 out of the 2182 cases could be due to the excess of exposure to the cement plant pollutants compared with the reference level (E0).

Table 3
Adults: exposure to NO_x and risks of hospital admission.

Exposure groups	Cases	Controls	Total	Crude OR	95% CI	Adj. OR[a]	95% CI
Overall analysis							
E0	267	646	913	1		1	
E1	1312	2306	3618	1.377	1.176–1.612	1.296	1.101–1.525
E2	603	1114	1717	1.310	1.101–1.558	1.161	0.971–1.388
Tot	2182	4066	6248				
p for trend				0.006			
AR[b]				22.98%			
Males							
E0	182	380	562	1		1	
E1	747	1368	2115	1.140	0.935–1.390	1.079	0.879–1.324
E2	338	637	975	1.108	0.889–1.381	0.952	0.757–1.199
Tot	1267	2385	3652				
p for trend				0.959			
AR[b]				9.84%			
Females							
E0	85	266	351	1		1	
E1	565	938	1503	1.885	1.445–2.458	1.753	1.336–2.299
E2	265	477	742	1.739	1.305–2.316	1.600	1.195–2.140
Tot	915	1681	2596				
p for trend				<0.001			
AR[b]				41.29%			
Age							
35–64 yrs							
E0	72	375	447	1		1	
E1	346	1139	1485	1.582	1.197–2.092	1.578	1.193–2.088
E2	147	423	570	1.810	1.322–2.479	1.813	1.324–2.483
Tot	565	1937	2502				
p for trend				0.001			
AR[b]				34.18%			
Age > 65 yrs							
E0	195	271	466	1		1	
E1	966	1167	2133	1.150	0.939–1.409	1.162	0.948–1.424
E2	456	691	1147	0.917	0.737–1.141	0.931	0.747–1.160
Tot	1617	2129	3746				
p for trend				0.469			
AR[b]				5.26%			

[a] OR adjusted for age and sex (overall), for age (males and females), or for sex (age subgroups).
[b] Attributable risk.

Sub-analysis by sex showed greater risks for females, with OR from 1.70 to 1.88 (from 1.60 to 1.75 when adjusted for age) and an attributable risk over 40% (378 out of 915 cases). The probabilities of risk for males were much lower (OR about 1.10, or around 1 when adjusted for age) and not statistically significant; consequently the attributable risk was also very low (less than 10%), estimating that 125 hospital admissions out of 1267 might have been due to the exposure.

The analysis stratified for age showed a higher risk for those under 65, with a significant trend with increasing levels of exposure: about 1.60 for the moderately exposed group and 1.80 for the highest exposed. The attributable risk of 34% indicated 193 hospital admissions out of 565 attributable to the plant pollution. The risks were not found in the older subjects: OR were near to 1 for both exposure levels (crude or adjusted for sex).

Table 4 reports sub-analyses on the two groups of pathologies (cardiovascular and respiratory), overall and separately for age. There were no major differences for the two pathologies: an association between exposure and risk appeared (though losing some significance on adjusting for age and sex), with no exposure–response trend for respiratory pathologies. For the adults under 65 the association was stronger (particularly hospital admissions for respiratory symptoms), while for older people the risks were absent.

3.2. Children

Exposure to air pollution appeared to have a stronger negative effect on children than on adults (Table 5). The overall risks are higher: 1.67 for the moderately exposed group (E1) compared to the less exposed (E0), and almost double (OR 1.90) for the most exposed children (E2), with a significant p for trend (<0.001).

The attributable risk indicated that 38% of all hospital admissions involving children (105/274) could be avoided if the NO_x concentration was not higher than 110 $\mu g/m^3$ in all the areas considered.

The analysis stratified by sex showed a slightly different situation from adults. The risk appeared clear in males (but without an increasing exposure–response trend), while for the females the OR, indicating an increasing risk, were not statistically significant. This might depend on the limited number of hospital admissions for young females. The attributable risks were not really different: 41% for the males (67/163 cases) and 33% for females (37/111).

Sub-analysis by age group showed lower risks (with a loss of statistical significance) for pre-school children (from 0 to 5 years), but even higher risks for school-age children (6–14), with an attributable risk higher than 50%.

3.3. Check analysis

Table 6 reports the analysis on trauma and injuries, considered overall and then stratifying for sex. We identified 1018 hospital admissions of all ages and sampled 3868 controls from the same population. The calculated OR did not show the same risk as for cardiovascular and respiratory causes: 1.15 (95% C.I. 0.89–1.47) for moderately exposed (E1), 1.11 (95% C.I. 0.85–1.46) for highest exposed (E2).

4. Discussion

Our results showed an increase in hospital admissions for pathologies potentially related to the exposure to air pollution due to plant

Table 4
Adults: exposure to NO_x and risks of hospital admission (sub-analysis for disease groups and age).

Exposure groups	Cases	Controls	Total	Crude OR	95% CI	Adj. OR[a]	95% CI
Cardiovascular diseases							
E0	206	646	852	1		1	
E1	939	2306	3245	1.277	1.073–1.520	1.177	0.984–1.409
E2	457	1114	1571	1.287	1.063–1.557	1.128	0.927–1.373
Tot	1602	4066	5668				
p for trend				0.011			
AR[b]				19.06%			
Cardiovascular diseases (age 35–64 yrs)							
E0	60	375	435	1		1	
E1	235	1139	1374	1.290	0.949–1.752	1.281	0.942–1.741
E2	112	423	535	1.655	1.174–2.332	1.654	1.173–2.331
Tot	407	1937	2344				
p for trend				0.012			
AR[b]				23.85%			
Cardiovascular diseases (age > 64 yrs)							
E0	146	271	417	1		1	
E1	704	1167	1871	1.120	0.897–1.398	1.123	0.900–1.403
E2	345	691	1036	0.927	0.730–1.177	0.933	0.734–1.185
Tot	1195	2129	3324				
p for trend				0.734			
AR[b]				4.02%			
Respiratory diseases							
E0	61	646	707	1		1	
E1	373	2306	2679	1.713	1.289–2.277	1.612	1.209–2.149
E2	146	1114	1260	1.388	1.014–1.900	1.182	0.857–1.630
Tot	580	4066	4646				
p for trend				0.160			
AR[b]				33.80%			
Respiratory diseases (age 35–64 yrs)							
E0	12	375	387	1		1	
E1	111	1139	1250	3.045	1.660–5.588	3.052	1.663–5.600
E2	35	423	458	2.586	1.323–5.054	2.658	1.357–5.206
Tot	158	1937	2095				
p for trend				0.010			
AR[b]				60.77%			
Respiratories diseases (age > 64 yrs)							
E0	49	271	320	1		1	
E1	262	1167	1429	1.242	0.891–1.731	1.257	0.900–1.754
E2	111	691	802	0.888	0.617–1.279	0.908	0.628–1.312
Tot	422	2129	2551				
p for trend				0.310			
AR[b]				8.78%			

[a] OR adjusted for age and sex (overall cardiovascular and respiratory diseases) or for sex (age subgroups).
[b] Attributable risk.

emissions. This appeared particularly strong for children, that are particularly susceptible to air pollution (Gouveia and Fletcher, 2000), but the adults presented significant risks too.

These results confirmed the findings of many epidemiological studies on health effects of air pollution (Boezen et al., 1999; Brauer et al., 2002; Calderón-Garcidueñas et al., 2007; Van der Zee et al., 1999; Wilson et al., 2004), showing how children are a particularly vulnerable population because they spend more time outdoors, are generally more active, and have higher ventilation rates than adults (Just et al., 2002; Ostro et al., 2001; Wiley et al., 1993).

The differences in risk between males and females, particularly adults, might reflect the fact that women spend more time at home than men, so the subjects' addresses are more indicative of the real exposure for women than for men.

All the sub-analyses on children (by sex or age) might be affected by the small number of the hospital admissions for children (274 in total), generating less stable results from a statistical point of view. For this reason, the risks calculated considering all the children had to be considered the most significant information.

The analyses on the older subjects (more than 64 years) depicted an apparently paradoxical situation: no risk was found, though older people, like children, are usually more sensitive to air pollution (Anderson et al., 2003; Katsouyanni et al., 2001). This might be explained by the presence of two hospices in the two municipalities. The two hospices are in fact in the area of maximum exposure, and could have lead to an oversampling of highly exposed controls. Moreover, it is also possible that a number of hospital admissions of these people were missing because some patients were treated by doctors inside the hospices.

From the point of view of public health, the attributable risks indicated that almost a quarter of adult hospital admissions and more than one third of children's admissions could be avoided if the plant emissions, expressed as average exposure concentrations of NO_x, were reduced to expose the whole population to the same level considered as the reference category in our study.

As the acute effects are often indicators of a chronic effect, the results can also be read in terms of a general increase of cardiovascular and respiratory diseases in this population.

It is important to note that the general standing is seriously compromised, also due to other air pollution sources (industrial sites, quarries, highways and major roads). NO_x values are generally more elevated in comparison with the average of Brescia province. There were no "secure zones" in the surroundings with null or low exposure: the lowest winter value is 83 $\mu g/m^3$. But we were able to distinguish between higher exposure and lower exposure zones. These differences allowed to assess health risk values.

The results do not describe health effects exclusively attributable to the cement plant. They represent an overall evaluation of the

Table 5
Children: exposure to NO_x and risk of hospital admission.

Exposure groups	Cases	Controls	Total	Crude OR	95% CI	Adj. OR[a]	95% CI
Overall analysis							
E0	28	182	210	1		1	
E1	149	580	729	1.670	1.079–2.584	1.676	1.079–2.602
E2	97	336	433	1.876	1.188–2.965	1.907	1.196–3.043
Tot	274	1098	1372				
p for trend				<0.001			
AR[b]				38.35%			
Males							
E0	17	115	132	1		1	
E1	90	322	412	1.891	1.080–3.311	1.913	1.088–3.365
E2	56	210	266	1.804	1.002–3.249	1.801	0.987–3.283
Tot	163	647	810				
p for trend				0.013			
AR[b]				41.32%			
Females							
E0	11	67	78	1		1	
E1	59	258	317	1.393	0.693–2.798	1.358	0.674–2.738
E2	41	126	167	1.982	0.957–4.107	2.071	0.985–4.353
Tot	111	451	562				
p for trend				0.012			
AR[b]				33.29%			
Age 0–4 yrs							
E0	20	106	126	1		1	
E1	107	424	531	1.338	0.793–2.256	1.342	0.795–2.265
E2	72	272	344	1.403	0.814–2.417	1.401	0.813–2.413
Tot	199	802	1001				
p for trend				0.065			
AR[b]				23.96%			
Age 5–14 yrs							
E0	8	76	84	1		1	
E1	42	156	198	2.558	1.144–5.716	2.662	1.186–5.975
E2	25	64	89	3.711	1.566–8.794	3.675	1.549–8.720
Tot	75	296	371				
p for trend				0.001			
AR[b]				58.46%			

[a] OR adjusted for age and sex (overall), for age (males and females), or for sex (age subgroups).
[b] Attributable risk.

Table 6
Exposure to NO_x and risks of hospital admission for trauma and injuries.

Exposure groups	Cases	Controls	Total	Crude OR	95% CI	Adj. OR[a]	95% CI
Overall analysis							
E0	122	532	654	1		1	
E1	586	2130	2716	1.199	0.966–1.490	1.146	0.894–1.471
E2	303	1158	1461	1.141	0.903–1.442	1.113	0.851–1.456
Tot	1011	3820	4831				
p for trend				0.503			
Males							
E0	78	338	416	1		1	
E1	344	1301	1645	1.146	0.872–1.506	0.999	0.722–1.381
E2	185	705	890	1.137	0.847–1.527	1.001	0.705–1.423
Tot	607	2344	2951				
p for trend				0.503			
Females							
E0	44	194	238	1		1	
E1	242	829	1071	1.287	0.900–1.840	1.383	0.935–2.045
E2	118	453	571	1.149	0.782–1.688	1.294	0.850–1.970
Tot	404	1476	1880				
p for trend				0.828			

[a] OR adjusted for age and sex (overall) or for age (males and females).

possible health effects due to the high air pollution levels, but, considering NO_x concentrations, the cement plant has a very important role.

To check that our findings were not due to a bias in the case–control selection, we applied the same methods to a group of pathologies potentially not related with air pollution, i.e. trauma and injuries. This kind of analysis, showing no relation between environmental exposure and those pathologies, can be read as reinforcement of our results.

5. Conclusions

We found an association between the exposure to the cement plant emissions and the risk of hospital admission for cardiovascular or respiratory causes, particularly strong for children. The cement plant certainly has an important role as a producer of air pollution. Though in the area considered there are also other important sources, these could not be considered as confounders for the health effects brought to light by this analysis, as their spatial distribution is not associated with the exposure to cement plant emissions.

Funding

This work was partially financed by the municipalities of Mazzano and Rezzato, Lombardy Region, Italy.

Acknowledgements

The authors are grateful to the municipalities of Mazzano and Rezzato for financial support; Brescia Local Health Unit for health data; Consulenze Ambientali for the iso-concentrations maps of NO_x; SEAT for geocoding; GIS Italia for help using ArcGis software; Roberto Carrara for the precious work of coordination; J. D. Baggott for revising the English.

References

Al-Neaimi YI, Gomes J, Lloyd OL. Respiratory illnesses and ventilatory function among workers at a cement factory in a rapidly developing country. Occup Med 2001;51:367–73.

Alvear-Galindo MG, Mendez-Ramirez I, Villegas-Rodriguez JA, Chapela-Mendoza R, Eslava-Campos CA, Laurell AC. Risk indicator of dust exposure and health effects in cement plant workers. J Occup Environ Med 1999;41:654–61.

Anderson HR, Atkinson RW, Bremner SA, Marston L. Particulate air pollution and hospital admissions for cardiorespiratory diseases: are the elderly at greater risk? Eur Respir J 2003;21:39–46.

Asubiojo OI, Aina PO, Oluwole AF, Arshed W, Akanle OA, Spyrou NM. Effects of cement production on the elemental composition of soils in the neighbourhood of two cement factories. Water Air Soil Pollut 1991;57–58:819–28.

Ballester F, Tenías JM, Pérez-Hoyos S. Air pollution and emergency hospital admissions for cardiovascular diseases in Valencia, Spain. J Epidemiol Community Health 2001;55:57–65.

Boezen HM, van der Zee SC, Postma DS, Vonk JM, Gerritsen J, Hoek G, et al. Effects of ambient air pollution on upper and lower respiratory symptoms and peak expiratory flow in children. Lancet 1999;353:874–8.

Brauer M, Hoek G, Van Vliet P, Meliefste K, Fischer PH, Wijga A, et al. Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. Am J Respir Crit Care Med 2002;166:1092–8.

Breslow NE, Day NE. Statistical methods in cancer research. The Analysis of Case–control Studies. IARC Scientific Publication 32Lyon: IARC Press; 1980.

Brockhaus A, Dolgner R, Ewers U, Krämer U, Soddemann H, Wiegand H. Intake and health effects of thallium among a population living in the vicinity of a cement plant emitting thallium containing dust. Int Arch Occup Environ Health 1981;48:375–89.

Calderón-Garcidueñas L, Franco-Lira M, Torres-Jardón R, Henriquez-Roldán C, Mejía-Barragán G, Valencia-Salazar G, et al. Pediatric respiratory and systemic effects of chronic air pollution exposure: nose, lung, heart, and brain pathology. Toxicol Pathol 2007;35:154–62.

Canpolat BR, Atimtay AT, Munlafalioglu I, Kalafatoglu E, Ekinci E. Emission factors of cement industry in Turkey. Water Air Soil Pollut 2002;138:235–52.

Ekinci E, Munlafalioglu I, Tiris M, Pekin AV. Characterization of cement plant emissions in Turkey. Water Air Soil Pollut 1998;106:83–95.

Gouveia N, Fletcher T. Respiratory diseases in children and outdoor air pollution in São Paulo, Brazil: a time series analysis. Occup Environ Med 2000;57:477–83.

Just J, Ségala C, Sahraoui F, Priol G, Grimfeld A, Neukirch F. Short-term health effects of particulate and photochemical air pollution in asthmatic children. Eur Respir J 2002;20:899–906.

Kabir G, Madugu AI. Assessment of environmental impact on air quality by cement industry and mitigating measures: a case study. Environ Monit Assess 2010;160:91–9.

Katsouyanni K, Touloumi G, Samoli E, Gryparis A, Le Tertre A, Monopolis Y, et al. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project. Epidemiology 2001;12:521–31.

Legator MS, Singleton CR, Morris DL, Philips DL. The health effects of living near cement kilns; a symptom survey of Midlothian, Texas. Toxicol Ind Health 1998;14:829–42.

Ostro B, Lipsett M, Mann J, Braxton-Owens H, White M. Air pollution and exacerbation of asthma in African-American children in Los Angeles. Epidemiology 2001;12:200–8.

Poloniecki JD, Atkinson RW, De Leon AP, Anderson HR. Daily time series for cardiovascular hospital admissions and previous day's air pollution in London, UK. Occup Environ Med 1997;54:535–40.

Prescott GJ, Cohen GR, Elton RA, Fowkes FGR, Agius RM. Urban air pollution and cardiopulmonary ill health: a 14.5 year time series study. Occup Environ Med 1998;55:697–704.

Rovira J, Mari M, Nadal M, Schuhmacher M, Domingo JL. Partial replacement of fossil fuel in a cement plant: risk assessment for the population living in the neighbourhood. Sci Total Environ 2010;408:5372–80.

Schuhmacher M, Bocio A, Agramunt MC, Domingo JL, de Kok HAM. PCDD/F and metal concentrations in soil and herbage samples collected in the vicinity of a cement plant. Chemosphere 2002;48:209–17.

Schuhmacher M, Domingo JL, Garreta J. Pollutants emitted by a cement plant: health risks for the population living in the neighbourhood. Environ Res 2004;95:198–206.

van der Zee SC, Hoek G, Boezen HM, Schouten JP, van Wijnen JH, Brunekreef B. Acute effects of urban air pollution on respiratory health of children with and without chronic respiratory symptoms. Occup Environ Med 1999;56:802–13.

Wiley J, Robinson J, Piazza T, Stork L, Pladsen K. Final report — study of children's activity patterns; 1993.

Wilson AM, Salloway JC, Wake CP, Kelly T. Air pollution and the demand for hospital services: a review. Environ Int 2004;30:1109–18.

Wong TW, Lau TS, Yu TS, Neller A, Wong SL, Tam W, et al. Air pollution and hospital admissions for respiratory and cardiovascular diseases in Hong Kong. Occup Environ Med 1999;56:679–83.

Yang CY, Chang CC, Tsai SS, Chuang HY, Ho CK, Wu TN, et al. Preterm delivery among people living around Portland cement plants. Environ Res 2003;92:64–8.