

## Environmental Health in Central and Eastern Europe

# Environmental Health in Central and Eastern Europe

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## **Dedication**

These Proceedings are dedicated to Professor Joseph Hartman (1942-2004) of Boise State University, one of the founding sponsors of the Central and Eastern European Environmental Health Conference series, a dedicated teacher and student advocate, and a talented researcher who encouraged greater collaboration between the environmental science and environmental health communities.

## **Preface**

The first Central and Eastern European Environmental Health Conference was convened in Prague, Czech Republic, on October 24, 2004. This conference had three primary objectives:

1. To gather scientists and students from the USA and Central and Eastern Europe (CEE) to discuss the magnitude of the problems in specific regions of Central and Eastern Europe;
2. To discuss improved methods for assessing exposure including biomarkers of exposure and integrated methods for predicting dose; and,
3. To discuss specific health effects associated with exposure to chemicals at these sites with a focus on developmental and reproductive health.

While the objectives of this conference were quite broad, the intent was to gather scientists from a range of disciplines to identify the major problems facing CEE countries where U.S. National Institute of Environmental Health Sciences and U.S. Environmental Protection Agency research would make a positive difference. Thus, the initial sessions sought to define the magnitude of the problems given the current knowledge. The subsequent sessions discussed methods of assessing both the extent of exposure and potential adverse effects associated with the release of hazardous chemicals in these countries.

## **Acknowledgments**

The organizers wish to thank the financial sponsors of this conference, whose generosity made it possible to convene this international meeting. They not only supported the conference activities, but also provided travel awards for many students and other conference participants, thereby greatly enhancing the breadth of the scientific discussions and the potential for future scientific collaborations. The financial sponsors included the Agency for Toxic Substances and Disease Registry (USA); BIOGENIX (Czech Republic); Boise State University (USA); SlovAm (Slovak Republic); the Superfund Basic Research Program of the National Institute of Environmental Health Sciences, National Institutes of Health, Department of Health and Human Services (USA); TerraChem, Inc. (USA); Texas A&M University System (USA); the U.S. Environmental Protection Agency (USA); Wellington Laboratories (Canada); Wellington Science USA, Inc. (USA); and the World Health Organization.

A number of other institutions also provided valuable support to the conference. These included the Cancer Research Institute, Slovak Academy of Sciences (Slovak Republic); Charles University (Czech Republic); Comenius University, Faculty of Natural Sciences, Environmental Section (Slovak Republic); Czech Technical University (Czech Republic); Masaryk University, Faculty of Informatics (Czech Republic); Slovak Medical University, Faculty of Public Health (Slovak Republic); Slovak University of Technology (Slovak Republic); EU Center of Excellence, Institute of Experimental Medicine (Czech Republic); Ministry of the Environment

(Czech Republic); National Institute of Public Health (Slovak Republic); Slovak Environmental Agency (Slovak Republic); and the State Institute of Public Health (Czech Republic).

Many thanks also go to the conference organizing committee, an inter-institutional, international group that included B. Anderson, R. Autenrieth, M. Avakian, J. Barich, J. Blaha, K. Blaha, E. Bruce, D. Carpenter, L. Cizmas, K. Daniel, P. Dimitriou-Christidis, K.C. Donnelly, W. Farland, A. Gillespie, J. Hartman, J. Hrebicek, W. Kovalick, R. Kreizenbeck, J. Lewtas, K. Mahutova, S. McDonald, T. McDonald, B. Mournighan, T. Phillips, P. Preuss, L. Reed, I. Rovny, L. Safe, S. Safe, J. Silvan, R. Sram, W. Suk, E. Tesarova, J. Volf, T. Voltaggio, N. White and M. Wiles. We wish to extend particular thanks to the many local scientists who made this conference successful, including R. Sram and J. Volf.

## **Introduction**

The first Central and Eastern European Environmental Health Conference (CEEHC) was held in Prague, Czech Republic, from October 24 – 27, 2004. The conference included more than 150 participants from 16 countries. During the three days of this conference, it became apparent that the scientists of this region have produced a remarkable body of information to characterize the frequency and severity of environmental health problems. In addition, data were presented from a number of ongoing studies designed to evaluate methods for reducing exposures or improving site remediation.

In many of the countries of the former Soviet Union, large blocks of land exist that were the sites of large industrialized zones. Often, these industrialized zones included a number of major industrial complexes involved in the production or manufacture of various products. For example, up to 80% of the petrochemicals of the former Soviet Union were produced in Sumgayit, Azerbaijan. The industrialized zone of Sumgayit housed a chlordane plant, a chloralkalai plant and a synthetic rubber plant, as well as other production facilities. It is not uncommon in many of these industrialized zones to find areas where environmental media contain elevated concentrations of a number of organic and/or inorganic contaminants. Workers employed in the industries that were located in these zones often lived nearby and in substandard housing. The combination of a severely impacted environment and poor housing conditions has resulted in significant numbers of individuals receiving elevated environmental exposures. Minimal information is available from which to accurately

characterize the human health impacts of many of these exposures. Even less information is available to understand the combined influence of genetics and nutrition on susceptibility to adverse health effects from these contaminants. Extensive research has been conducted by investigators in Central and Eastern Europe to evaluate these problems. This includes research to measure contaminant levels in the environment, studies to monitor biomarkers in exposed populations, and studies to investigate the incidence of disease. In addition, novel approaches are being investigated to identify appropriate procedures to contain and remediate these contaminated environments. The results from these and other environmental health studies in this region will be of value to health professionals in the region. In addition, it should be emphasized that these results may also be used by health professionals from around the world to implement methods to prevent exposures and thereby reduce disease.

Many of these research projects are described in these proceedings, which represent approximately one-quarter of the presentations from the conference. For most of the authors, English was not their first language. The manuscripts were edited as needed to improve the clarity, and all changes were reviewed by the authors prior to publication. These proceedings provide a useful venue for publicizing the current state of environmental health science research in Central and Eastern Europe.

Many of the senior scientists from the United States and Europe who attended the meeting noted that the quality of the students who were present, including those from the Central and Eastern European countries, was outstanding. We hope that these conference proceedings will help these students develop their careers, and will serve as a catalyst to expand collaboration between scientists within this region as well as with scientists in other parts of the world.

## CHAPTER 1

# MORTALITY IN NORTHWESTERN BOHEMIA IN PERIODS OF HIGH AND LOW AIR POLLUTION

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**Abstract:** Air pollution was higher in the industrial area of Northwestern Bohemia during the years 1982 – 1990 than from 1991 to 2000. The aim of the study was to determine whether daily total, cardiovascular (CVD) or respiratory mortality in this area was significantly different during the years 1982 – 1990 compared to the period 1991 – 2000. Poisson regression analyses were conducted with standardized daily mortality as the resulting variable, the time period as the variable of interest, and standardized daily mortality in the rest of the Czech Republic, day of the week, temperature, relative humidity and influenza as confounders. During the period 1982 – 1990, the average concentrations for SO<sub>2</sub> and total suspended particles (TSP) were 103 and 102 µg/m<sup>3</sup>, respectively, and from 1991 – 2000 they were 45 and 62 µg/m<sup>3</sup>, respectively. This reduction is thought to be a consequence of the reduction in combustion of brown coal. The yearly age-standardized total mortality was substantially higher in the period with higher air pollution (15.1 deaths/1000 in men and 13.8/1000 in women) than during the period with lower air pollution (13.5/1000 and 12.6/1000 in men and women, respectively). CVD mortality also dropped following the reduction in air pollution, from 7.6/1000 to 6.6/1000 in men and from 8.3/1000 to 7.4/1000 in women. The influence of air pollution period was assessed. For all ages, the relative risk (RR) and 95% confidence interval were: for total mortality in men, 1.055 (1.037, 1.074), and in women, 1.025 (1.007, 1.043); for CVD mortality in men, 1.087 (1.061, 1.114), and in women, 1.054 (1.031, 1.078); and for respiratory mortality in men, 1.331 (1.24, 1.43), and in women, 1.049 (0.964, 1.143). The RR was between 2.5%-33% depending on gender, cause of death and age group. The influence of the time period (1982 – 1990 or 1991 – 2000) was stronger for younger age groups, for CVD, and for men.

**Key words:** Northwestern Bohemia, coal burning, power plant, heating, mortality, standard, standardization, gender, age, cause of death, air pollution, Poisson regression, temperature, humidity, influenza.

## 1. INTRODUCTION

There is widespread concern about the potential adverse health effects of ambient air pollution. Studies of extreme episodes of air pollution in the Meuse Valley, Donora and London have provided compelling documentation of the serious adverse effects of this pollution on human health.

A remarkably consistent association between short term changes in daily mortality and particulate air pollution has been found in several US cities, (Dockery et al., 1992, 1993, Pope III et al., 1992, Schwartz, 1993, 1994, 1994, Schwartz and Dockery, 1992) Brazil and China (Saldiva et al., 1995, Xu, et al., 1994). Similar results have been obtained in 15 European cities from different countries within the Air Pollution and Health – A European Approach (APHEA) project (Katsouyani et al., 1996, 1997, Zmirou et al., 1996, Dab et al., 1996, Spix and Wichmann, 1996, Touloumi et al., 1996, Vigotti et al., 1996, Sunyer et al., 1996, Bacharova et al., 1996), as well as in studies concerning short term effects of air pollution on daily mortality in Northwestern Bohemia (Kotesovec et al., 2000) and Northern Bavaria (Peters et al., 2000).

Recent studies suggest that respirable particles are the causal factor responsible for the increase in daily mortality associated with increasing air pollution, whereas SO<sub>2</sub> is considered to be only an indicator of air pollution. Additional studies suggest that SO<sub>2</sub> or other air pollutants may act as independent factors (Xu et al., 1994, Zmirou et al., 1996, Spix and Wichmann, 1996, Bacharova et al., 1996).

Studies that present evidence of diminished daily mortality or increased life-expectancy following reduction in air pollution are rare. After the Irish government banned the marketing, sale and distribution of bituminous coal within the city of Dublin, a study in Ireland (Clancy et al., 2002) found a significant decrease in age-standardized total, cardiovascular and respiratory mortality following adjustment for temperature, humidity, day of week, respiratory epidemics and death rates in the rest of Ireland. This intervention was followed by an immediate and permanent reduction in particulate air pollution.

Until 1990, brown coal was used in Northern Bohemia by power plants, all industrial plants, and households, to produce energy and heat. Emission concentrations, particularly of SO<sub>2</sub> and particulate matter, reached levels

which were the highest in the Czech Republic and among the highest in Europe. After interventions in 1989 and 1990 (dust elimination and desulphurisation of power plants and changes in local heating from coal to gas), the level of air pollution decreased rapidly and remained low.

The aim of this study was to determine whether there was an association between air pollution and cause-specific mortality, and to evaluate whether age or gender influenced this association.

## 2. STUDY LOCATION

The study area is the gray area shown in Figure 1. As can be seen in this map, power plants and other major sources of pollution are concentrated in and around this region.

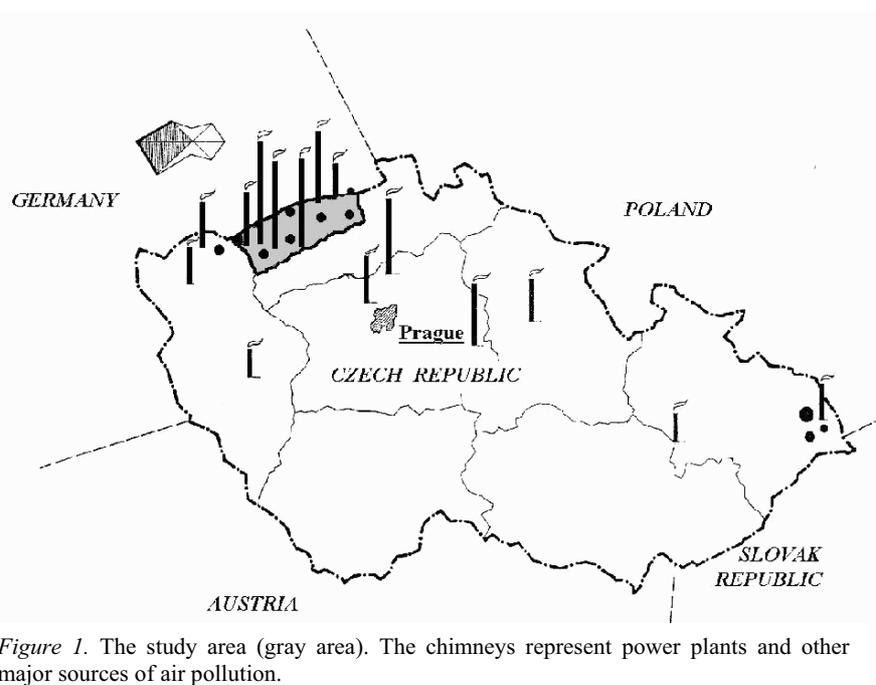


Figure 1. The study area (gray area). The chimneys represent power plants and other major sources of air pollution.

## 3. METHODS

The goal of this study was to determine if the period of high air pollution (1982 – 1990) was associated with changes in age-standardized mortality when compared with the period of relatively lower air pollution (1991–

2000). Air pollution was measured daily in the study area during the period 1982 – 2000. The goal of the study was to establish if the indicator of the period of high air pollution in the industrial area in Northwestern Bohemia in the years 1982 – 1990, compared with the period of relatively lower air pollution in the years 1991 – 2000, was associated with changes in age-standardized daily mortality. A similar study was conducted in Ireland (Clancy et al., 2002), where the periods before and after banning the sale of coal in Dublin were considered.

Data were available on daily mortality in the study area and in the Czech Republic as a whole, which served as the reference area. The data were stratified according to gender and cause of death, and population counts in five-year age groups were also available. For the present study, mortality data were indirectly age-standardized. In this method, the number of deaths in each age group (15-year intervals for 0-74 years and 5-year intervals for age 75 and older) in the reference area was multiplied by the ratio of the population in the study area to the population in the reference area for this age group. Thus, for each age group, the expected number of cases in the study area was calculated and the sum of the expected numbers was divided by the actual number of deaths in the study area. This was done separately for each gender, all causes of death, and all ages, and for the age groups <60, 60-74 and over 75. Multiplying this coefficient, called the SMR (standardized mortality ratio), by cause-specific mortality in the reference area per 100,000 inhabitants, yielded the standardized mortality in the study area. This method was used because the daily count of deaths in each age-group, particularly for cause-specific mortality in the study area, was often equal to zero while in the reference area the numbers were generally much higher. The method of indirect standardization uses only the total count in the study area and counts within age groups of the reference area for both genders and all considered causes of death.

The S-plus software package was used for evaluating the influence of the indicator of the period of high air pollution. The Procedure GAM (Generalized Additive Models), Poisson regression using the LOESS function to control for mortality in the rest of the Czech Republic, and meteorological variables were applied. The LOESS function is a method of piecewise regression where the size of the regressed part is defined by the parameter span. The right size should be chosen to fit the trends but should not be influenced by random fluctuation. For standardized mortality in the reference area and relative humidity we used span 0.8, for temperature 0.5.

Standardized daily mortality was considered to be a resulting dependent variable, and the indicator of the period was considered a variable of interest. The confounders were as follows:

1. standardized daily mortality in the rest of the Czech Republic

The standardized daily mortality was stratified and obtained in the same way as the mortality in the study area (described previously). The daily mortality in the rest of the Czech Republic was used to fit long-term trends caused by changes in life style (nutrition, smoking) or in medical care, and seasonal patterns. This variable in the model was highly significant in all cases except with women <60.

2. day of week was included for compatibility with other studies but did not prove to be significant.

3. temperature proved to be highly significant except with people <60. The lowest mortality was at about 15 °C.

4. relative humidity was again included for compatibility with other studies but did not prove to be significant.

5. influenza: weekly counts of influenza were available for all districts, and were used to calculate daily numbers using a seven-day moving average. This factor was highly significant except with people <60.

#### 4. RESULTS

Average yearly concentrations for SO<sub>2</sub> and total suspended particles (TSP) were 103 and 102 µg/m<sup>3</sup>, respectively, during 1982–1990, and 45 and 62 µg/m<sup>3</sup>, respectively, during 1991–2000, following dust separation and desulphurization of power plants and the shift from changes from coal to gas in home heating.

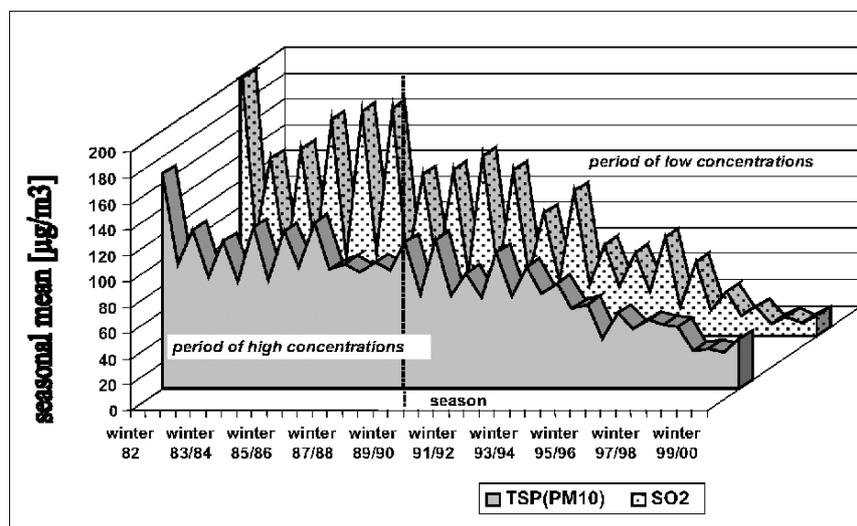


Figure 2. Seasonal concentrations of air pollutants. (Note: TSP = total suspended particles; particulate matter <10 µ m)

During the entire period of the study, the mean TSP and SO<sub>2</sub> concentrations in the study area were generally higher in winter seasons. During the period 1991 – 2000, the reduction in TSP and SO<sub>2</sub> was evident in all months, but the largest decline was noted in the winter (Figure 2).

Table 1. Yearly mean standardized mortality/1000 in periods of high and low air pollution.

Mortality	total		CVD		respiratory	
Gender	male	female	male	Female	male	female
high air poll.period	15.07	13.80	7.64	8.35	0.92	0.54
low air poll.period	13.49	12.59	6.65	7.42	0.60	0.45
Change	-1.58	-1.21	-0.99	-0.92	-0.32	-0.09
change[%]	10.50	-8.75	-12.94	-11.06	-34.42	-16.37
stat.significance	signif.	signif.	signif.	signif.	signif.	signif.

An average of 7,265 total deaths per year were recorded during the period of high air pollution, compared to an average of 6,867 total deaths per year during the period of lower air pollution (398 fewer deaths per year on average). Cardiovascular diseases (CVD) were responsible for approximately 51% of deaths in men and 61% in women. Respiratory diseases accounted for 5% of male and 4% of female deaths.

Mean age-standardized total non-trauma death rates as well as CVD and respiratory death rates also differed by season, with the highest mortality rates in the winter (Figure 3). The age-standardized total, CVD and respiratory mortality significantly decreased in the period with lower air pollution (Table 1).

Standardized mortality in the rest of the Czech Republic, in relation to daily temperature and the incidence of influenza were statistically significant for all groups except people younger than 60. On the contrary, relative humidity and day of the week did not appear to affect the mortality rate.

Table 2 presents the percent change in age-standardized mortality in Northwestern Bohemia during the periods of high and low air pollution. After adjusting the Poisson regression for temperature, humidity, day of the week, respiratory epidemics and age-standardized death rates in the rest of the Czech Republic, there was a significant change in total and CVD mortality for both genders and for respiratory mortality in men when these parameters were compared for the periods of high and low air pollution. The effects were mostly greater for men except age group <60. The effects were

larger for CVD than for total mortality. The greatest effect was observed for respiratory mortality in men, but due to the low number of cases in this category, this result should be interpreted with caution.

For men as well as for women, greater effects were observed for the age group <60 but again it should be noted that there were low numbers of cases in these categories, particularly for women (Figure 4).

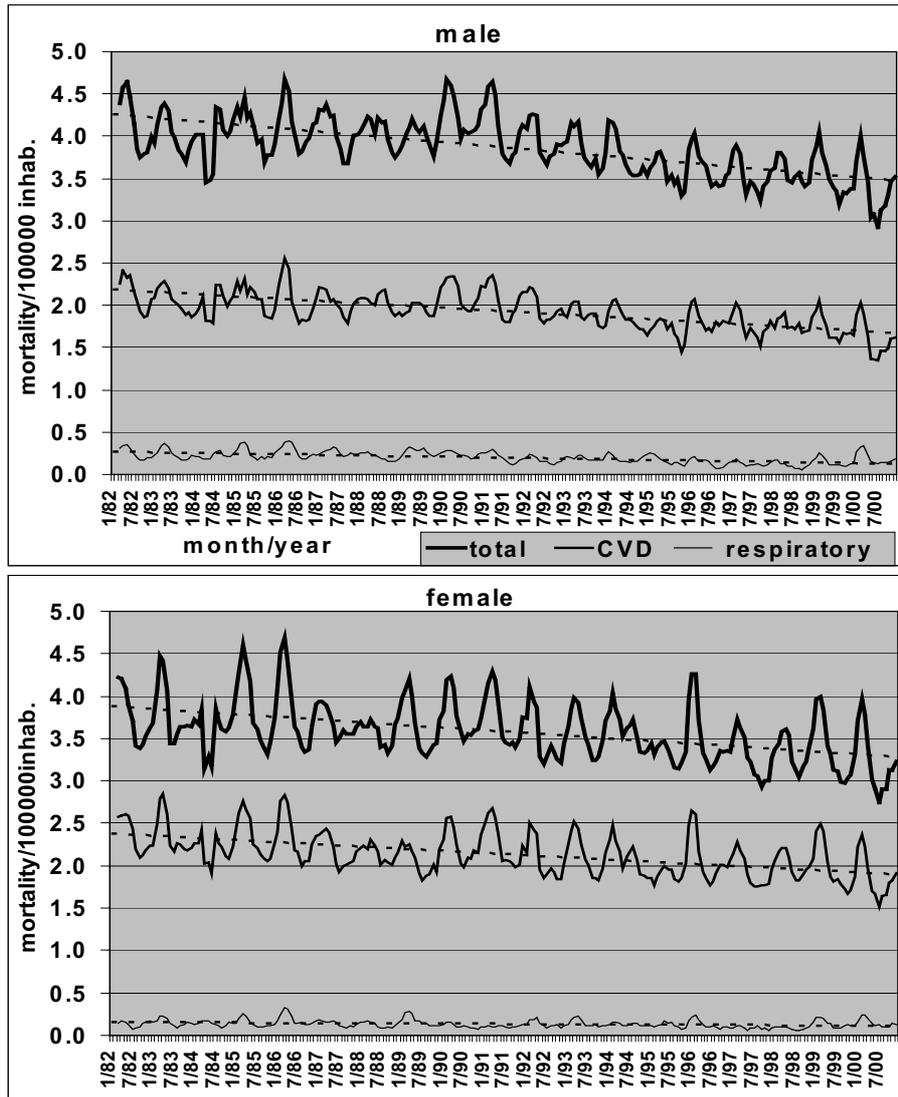


Figure 3. Mean age-standardized total non-trauma mortality rates in the study area for men and women for the period 1982 – 2000. (Note: inhab. = inhabitants).

## 5. DISCUSSION AND CONCLUSION

The substantial decrease in air pollution was followed by a decrease of 5.5% (men) and 2.5% (women) in age-standardized total mortality adjusted for temperature, humidity, incidence of respiratory diseases, day of week and death rates in the rest of the Czech Republic. The decrease in the cardiovascular death rate was 8.7% in men and 5.4% in women. The largest decrease was seen in estimated respiratory mortality in men (33.1%), whereas the decrease in respiratory mortality among women was not significant (4.9%). When the mortality was evaluated with regard to age, then the decrease in total and CVD mortality was generally highest in men as well as in women younger than 60 years.

Table 2. Adjusted relationship between indicator of air pollution period and mortality via Poisson regression.

Cause of death	Gender	Age	Stat. signif.	% Change (95% CI)
all	male	all	***	5.5 (3.7, 7.4)
all	female	all	**	2.5 (0.7, 4.3)
CVD	male	all	***	8.7 (6.1, 11.4)
CVD	female	all	***	5.4 (3.1, 7.8)
all	male	<60	***	9.9 (6.8, 13)
all	female	<60	***	11.3 (6.6, 16.1)
CVD	male	<60	***	16.3 (10.5, 22.4)
CVD	female	<60	***	25.2 (15, 36.2)
all	male	60 – 74	***	6.7 (3.9, 9.6)
all	female	60 – 74	**	4.2 (1.1, 7.4)
CVD	male	60 – 74	***	10.4 (6.4, 14.5)
CVD	female	60 – 74	***	7.8 (3.5, 12.3)
all	male	≥ 75	***	8.3 (5.1, 11.6)
all	female	≥ 75	**	3.3 (1, 5.7)
CVD	male	≥ 75	***	10 (6, 14.1)
CVD	female	≥ 75	***	6.4 (3.6, 9.3)
respir.	male	all	***	33.1 (24, 42.8)
respir.	female	all	n.s.	4.9 (-3.6, 14.3)

Statistical significance: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ , n.s.  $p > 0.05$

Clancy and colleagues found a rapid reduction in air pollution to be associated with significant decreases in total mortality (5.7% decrease), CVD mortality (10.3% decrease) and respiratory mortality (15.5% decrease).