SMR are higher in the metropolitan dwellers. and low deprivation categories are clear and metropolitan areas, those in the low and high classification of deprivation, with one exception: levels of deprivation the point estimates for Discussion

The results for death from accident, violence, and poisoning are particularly intriguing, and might be clearer if suicide and traffic accidents were tabulated separately. The category "non-metropolitan" includes a variety of areas (mainly urban to rural), and a finer classification might have produced different results. Any finer classification of cause of death would, however, be at the expense (at least in this data set) of loss of statistical power. Furthermore, the L.S offers almost impossible possibilities for analysis and there is a clear risk of dredging the data to find results which accord with preconceived notions. My view is that more understanding will come, not from yet more refinement in statistical studies, but rather from descriptive case studies. A significant association between black smoke and three of the four outcomes in the study was found. The estimated relative risk (RR) of dying corresponding to a 10 µg/m³ increase in mean daily black smoke over the whole period was 1.099 (95% confidence interval (95% CI): 1.003, 1.100). For mortality in the group aged more than 70 years and for cardiovascular mortality, the RRs were 1.008 (95% CI: 1.001, 1.016) and 1.012 (95% CI: 1.003, 1.022) respectively. The association between SO2 and mortality is less clear: it was only evident during the warm season. The estimated RRs in this case were 1.007 (95% CI: 0.996, 1.018) for total mortality, 1.010 (95% CI: 1.000, 1.011) for mortality from respiratory diseases and 1.012 (95% CI: 0.995, 1.026) for cardiovascular deaths. No significant association was found between mortality from respiratory diseases and either of the two pollutants. Conclusions - A positive relationship between air pollution and mortality was found in the short term, as has been shown in many previous studies. Although the current levels of air pollution in Valencia are not very high, they could have an effect on the number of premature deaths. Despite the fact that the association is weak, it is important at the public health level because of the number of population exposed and the possibility of establishing control measures.

Results

Abstract

In recent years, a growing number of epidemiological studies have suggested that increases in air pollution exposure are associated with increases in daily mortality, even where levels of pollutants are below those considered as safe. Most of the existing literature is from investigations carried out in the USA, which show that particulate matter is the air pollutant which exhibits this relationship most clearly.1-3 In Europe, a series of investigations has also been carried out but with more diverse results in terms of the pollutants with the strongest association (in many cases it has been SO2, but not particulate matter), and because of difficulties in comparing results, the methods of these studies have been used to determine the concentrations of pollutants or different methodologies may have been used for the epidemiological analysis.1-4 In Valencia, air pollution is not currently regarded as a serious problem and there are no previous published reports on air pollution and mortality. Towards the end of 1993 we began a study which aimed to examine whether there was an association between pollution and mortality in Valencia as elsewhere. We undertook this study using the APHEA protocol which has been described previously. This European project began in 1992 and has developed an extensive and valuable database from 10 countries with different social, climatic, and environmental conditions. We present here the results of a study which have been a cornerstone in epidemiological analysis of the time series data from the APHEA study.

Methods

Introduction

This was an ecological study using time series data to which Poisson regression was applied. Daily variations in several selected causes of death were related with daily variations in air pollution levels for the period 1991-93.

STUDY AREA

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Journal of Epidemiology and Community Health 1996;50:327-333

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obtained from the Valencian community's mortality register. The group to be studied was restricted to the city’s residents only. There have been many published reports on the completeness of the register and the quality of patient diagnosis and the cause of death data that was considered as inadequate. As a result, the values used to measure air pollution are those obtained from an average of the three remaining stations. The percentage of days with missing values in any one of the three selected sets varied between 6% and 13% for black smoke, and between 8% and 13% for SO\(_2\). The sets are located within the urban area of Valencia with a median level of vehicular traffic. Motor vehicles are considered one of the principal sources of pollutant emission given that there is not a great deal of heavy industry in the city and people do not often burn fuels for heating because of the mild climate during the winter.

METEOROLOGICAL DATA

The mean daily temperature and relative humidity figures were obtained from the National Institute of Meteorology’s weather station in the Meteorological Centre of Valencia. This location was considered more representative than another one near the city, situated at the airport given that in various studies the effects of the thermal island, which is produced in the city of Valencia, showed up. This effect consists of the modification of the temperature fields produced by large urban agglomerations. In the city of Valencia, its magnitude varies from almost nil values when there are strong winds to over 6°C in anticyclonic situations with clear skies and slight winds.

Influenza

In Spain there is a monitoring procedure for notifiable diseases that involves the Public Health Network. The quality of this register has also been evaluated and shows a good level of coverage in the Valencia region. The number of cases of influenza registered weekly was obtained from the epidemiological services of the city of Valencia, and this total was divided by seven to obtain an approximation of the daily incidence of influenza. The use of the variable with continuous data was preferred to the construction of a variable dummy with only two possible values, epidemic and non-epidemic periods.

Analysis

The analysis procedure followed to assess the relationship between mortality and pollutants is based on that of the APAHEA project and is explained in more detail elsewhere. This ensures the comparability of the results with those obtained in the other cities of the study. In our case, this approach consisted of the following.

Identification of the core model

Identifying a core model, by means of the least squares regression method, was undertaken for each of the causes of mortality studied. For this purpose, the following factors were taken into account:

1. Seasonality. For this the sinusoidal terms up to the 6th order were tested. The criteria to decide on the order and cos terms to be included in the model were, either, when they jointly improved the model (P of change on introducing them jointly <0.10), or when one of them (sin or cos of the same order) remained significant (p<0.05) with the final model.

2. Temperature and humidity. Both were introduced into the linear form model, this being the form with the best adjustment. The lags were tested jointly for both variables up to two days before, setting the selection according to its adjustment.

3. Long term trends. A trend variable was introduced for the whole period and a dummy variable was tested for each year. An additional seasonality control was carried out preserving the year-indicating variables within the models and introducing the interactions of these variables with trigonometric functions.

4. Day of the week and holiday. Six dummy variables were tested for the days of the week, taking Monday as the base. These variables were maintained in the model on the basis of statistical significance (P-test for all six variables <0.10). The “holiday” variable was introduced separately into the model, for the same criteria for maintaining it.

5. Influenza incidence, in continuous form, as mentioned above. Its lags from 1 to 15 were tested.

Selection of the air pollution variables

Each pollutant was studied separately in order to avoid multicollinearity. The residuals of mor­

tality and of each pollutant after applying the core model were plotted to decide if the pol­
lution variables were transformed. Also tested in the model was the log-transformation of the number of deaths, but this only improved the model better, it was the one finally chosen.

Subsequently, the lags of each pollutant were tested (up to 5 days in each case) in the current lag with best adjustment. This was performed in similar fashion with the averages of 2, 3, and 4 days, including lag 0 in all cases.

Final Poison regression models

With the models defined in the previous stage the final models were built using the Poisson regression. Four final models were obtained for each pollutant. In the first two cases the variable used as a pollution indicator was either the current lag (one day measurement) or the cumulative (average) selected in the previous stage. In the other two cases it was the same as in the previous case, including additionally a dummy variable for the season (1 if month = from November to April “cold season”, and 0 if month = from May to October “warm season”) in the model, plus an interaction term for the air pollutant and the seasonal variable in order to assess modification effect in relation to season.

When the seasonality terms were introduced, qualitative changes were seen in some of the groups studied, and we proceeded to carry out an analysis stratified by season. In all cases the possible autocorrelation of mortality residues was checked, along with the significance of the parameters up to the second order.

Finally, the interaction between black smoke and SO\(_2\) was investigated, since a dummy variable was created for black smoke (cut off point for “low” versus “high” - 100 µg/m\(^3\) ) and the interaction term between the said variable and SO\(_2\) was introduced into the SO\(_2\) model with no statistical significance in the dummy variable was not created for SO\(_2\) since for the Valencian data there was only one day during which the cut off point was reached in the pro­
cedures of the APAHEA project (100 µg/m\(^3\) ) was exceeded.

Results

Table 1 summarises the average daily mortality values, the levels of black smoke and SO\(_2\), as well as the average temperature and relative humidity in relation to the whole period and the two seasons in the study. In Valencia there

<table>
<thead>
<tr>
<th>All year</th>
<th>Winter months</th>
<th>Summer months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Total mortality</td>
<td>11.68 4.05</td>
<td>12.70 3.99</td>
</tr>
<tr>
<td>Total mortality age 70+</td>
<td>12.07 4.11</td>
<td>13.25 4.12</td>
</tr>
<tr>
<td>Cardiovascular mortality</td>
<td>11.18 4.03</td>
<td>12.10 3.99</td>
</tr>
<tr>
<td>Ischaemic heart disease mortality</td>
<td>11.18 4.03</td>
<td>12.10 3.99</td>
</tr>
<tr>
<td>Congestive heart failure mortality</td>
<td>11.18 4.03</td>
<td>12.10 3.99</td>
</tr>
<tr>
<td>Cardiomyopathy mortality</td>
<td>11.18 4.03</td>
<td>12.10 3.99</td>
</tr>
<tr>
<td>Influenza mortality</td>
<td>3.40 0.72</td>
<td>3.04 0.74</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>17.51 5.12</td>
<td>22.05 4.12</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>67.65 13.15</td>
<td>63.48 12.23</td>
</tr>
</tbody>
</table>

Winter months = May, June, July, August, September, October; Cold months = November, December; January, February, March, April.

Table 1: Daily mortality in the groups studied, air pollutant values (µg/m\(^3\) ), and meteorological data, Valencia, Spain 1992-93
were a third more deaths in winter than in summer. The seasonal variations for the two pollutants in the study were not very large, and in the case of SO₂ were quite low (0.63 to 0.76), but was lower for SO₂ (between 0.14 and 0.63). Between the means of the three stations for black smoke and SO₂, the correlation was also quite low (0.24).

In comparing the pollutant measured at the station giving the maximum values to those measured at the station giving the minimum values, we again found a different trend between the two pollutants. Whereas in the case of black smoke the levels measured at the station with the highest values were more than double those measured at the station with lowest values, in the case of SO₂ there was much less variation – approximately 20% more.

The correlation between the three monitoring stations was relatively high for black smoke (between 0.63 and 0.76), but was lower for SO₂ (between 0.14 and 0.63). Between the means of the three stations for black smoke and SO₂, the correlation was also quite low (0.24). In comparing the pollutant measured at the station giving the maximum values to those measured at the station giving the minimum values, we again found a different trend between the two pollutants. Whereas in the case of black smoke the levels measured at the station with the highest values were more than double those measured at the station with lowest values, in the case of SO₂ there was much less variation – approximately 20% more.

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monitoring of air pollution, an effect should be madeclearly elaborated in this type of study.

This is the first study of the short term effects of air pollution on mortality carried out in Valencia. The results obtained are consistent with those from other European cities. They are, however, more similar to those obtained in Athens, where the association between air pollution and mortality is clearer for particulate matter than for $SO_2$. Over the past few years, there have been various reviews of the topic. In these reviews, the authors resolve the problems of comparability of results between cities or even countries. In American studies, where the association between air pollution and mortality is clearer, the association is a weak one, but it is nevertheless statistically plausible, especially in the case of the association with cardiovascular mortality. It has been argued that as well as the misclassification of causes of death, respiratory infections contribute to a higher number of deaths during the warmer months, although the results are not very significant. In conclusion, the association found shows a positive relationship between air pollution and mortality in the short term, as has been witnessed in a considerable number of investigations carried out elsewhere. These findings suggest that although the association with particulate air pollution in the city of Valencia is not very high, it would have an effect on the number of premature deaths. The association is a weak one, but it is nevertheless important at a public health level, since the numbers of population exposed and to the possibility of establishing control measures.