

# Effects of Air Pollution on Daily Mortality in Lisbon: Implications for Tourism

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## Introduction and objective of the study:

Ambient air quality is a key indicator used for the Quality Performance Evaluation (QUALITEST) of tourist destinations. Bad air quality can lead to respiratory and cardiovascular illness and can have an influence on the tourists perception of the destination. Since bad air quality affects the health of both tourists and residents it is important to monitor the destination's air quality as well as associated health impacts.

This study evaluates the association between exposure to air pollutants and daily mortality in Lisbon, Portugal, from 2000 to 2004.

## Material and methods:

### Health data

Daily mortality data was obtained from National Institute of Statistics (INE). The mortality data were classified as cardiovascular diseases (ICD-9 codes 390-459; ICD-10 I00-I99) and respiratory diseases (ICD-9 codes 460-519; ICD-10 J00-J98).

### Air pollution and weather data

Daily air pollution data for ozone (O<sub>3</sub>), sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), and particulate matter <10µm in aerodynamic diameter (PM<sub>10</sub>) were collected by the Portuguese Environment Institute (APE). We calculated the 24-hr average concentration of SO<sub>2</sub>, NO<sub>2</sub>, and PM<sub>10</sub> and 8-hr average concentration for O<sub>3</sub>. Daily meteorological data were obtained from the Portuguese Meteorological Institute.

### Statistical analysis

The associations between daily mortality and air pollutants were estimated using generalized additive models (GAM). Explanatory variables were time, meteorologic variables, and pollutant concentrations.

We incorporated smoothed spline functions of time and weather conditions, to control seasonality and time trends. The effects of weather variables and air pollutants recorded on the same day and lagged from 1 to 3 days were investigated.

Analyses were done for all year and for summer season only (May to September).

The results are presented as the percent change in daily mortality per 10µg/m<sup>3</sup> increase in the concentration of air pollutants.

## Results:

Table 1 presents the descriptive statistics for mortality, air pollution and meteorological variables in Lisbon, from 2000 to 2004. On average, there were 24.1 deaths/day from cardiovascular diseases and 4.8 from respiratory diseases. In our research period the mean daily concentration of PM<sub>10</sub> was 32.5 and O<sub>3</sub> was 69.5, the lowest mean concentration was observed for SO<sub>2</sub>.

Table 1. Summary of the descriptive statistics for mortality, air pollution and meteorological variables in Lisbon, 2000-2004.

Variable	Mean	SD	Minimum	Median	Maximum
<b>Daily death counts</b>					
Cardiovascular	24.1	7.0	7.0	23.0	53.0
Respiratory	4.8	2.9	0.0	4.0	23.0
<b>Air pollutant</b>					
PM <sub>10</sub> 24h (µg/m <sup>3</sup> )	32.5	18.6	7.3	27.6	192.0
NO <sub>2</sub> 24h (µg/m <sup>3</sup> )	36.3	27.9	6.1	27.3	228.8
SO <sub>2</sub> 24h (µg/m <sup>3</sup> )	4.2	4.7	0.1	2.7	65.0
O <sub>3</sub> 8h (µg/m <sup>3</sup> )	69.5	24.8	5.8	67.9	162.1
<b>Meteorologic measures</b>					
Mean temperature(°C)	17.2	5.0	5.2	16.6	33.9

In whole year analysis, there were significant associations between PM<sub>10</sub>, O<sub>3</sub> and NO<sub>2</sub> and cardiovascular mortality (table 2). An increase of 10µg/m<sup>3</sup> in PM<sub>10</sub> concentration at current day corresponds to 1.15% (0.60; 1.71) increase in cardiovascular mortality.

In the warm season, O<sub>3</sub> and NO<sub>2</sub> were significantly associated with cardiovascular mortality after a short period of exposure (2 days).

Table 2. Percent increase (95%CI) of cardiovascular mortality associated with a 10µg/m<sup>3</sup> increase in the concentration of pollutants, Lisbon, 2000-2004.

Pollutant*	Whole year			Warm season		
	Lag	%	95% CI	Lag	%	95% CI
PM <sub>10</sub>	0	1.15	0.60; 1.71	2	1.47	0.47; 2.48
O <sub>3</sub>	3	-0.81	-1.25; -0.37	2	1.97	1.25; 2.69
NO <sub>2</sub>	3	1.19	0.82; 1.56	2	2.72	1.59; 3.85

\*only significant results

For respiratory mortality we found significant associations only with exposure to O<sub>3</sub> and NO<sub>2</sub> (table 3) in whole year and summertime. An increase of 10µg/m<sup>3</sup> in O<sub>3</sub> and NO<sub>2</sub> concentration at lag 2 was associated with 1.84% and 1.23% excess in respiratory deaths.

Table 3. Percent increase (95% CI) of respiratory mortality associated with a 10µg/m<sup>3</sup> increase in the concentration of pollutants, Lisbon, 2000-2004.

Pollutant*	Whole Year			Warm season		
	Lag	%	95% CI	Lag	%	95% CI
O <sub>3</sub>	2	1,84	0,29; 3,43	2	1,85	1,04; 3,77
NO <sub>2</sub>	2	1,23	0,37; 2,09	2	-1,42	-3.98; 1.21

\*only significant results

## Conclusions:

- Air pollution, at current levels in Lisbon, may represent a risk for cardiovascular and respiratory health among the urban population.
- As Lisbon is one of the most popular tourist destinations in Portugal, it is important to take mitigation actions now to ensure that air quality does not worsen. Any reductions in air quality is likely to have negative implications for resident and tourist health which could lead to reduced Quality Performance Evaluation (QUALITEST) of Lisbon as a tourist destination.

## References

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