Winter air-mass-based synoptic climatological approach and hospital admissions for myocardial infarction in Florence, Italy

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Abstract

The aim of this study was to evaluate the relationship between the risk of hospital admission for myocardial infarction (MI) and the daily weather conditions during the winters of 1998–2003, according to an air-mass-based synoptic climatological approach. The effects of time lag and 2-day sequences with specific air mass types were also investigated. Studies concerning the relationship between atmospheric conditions and human health need to take into consideration simultaneous effects of many weather variables. At the moment few studies have surveyed these effects on hospitalizations for MI. Analyses were concentrated on winter, when the maximum peak of hospitalization occurred. An objective daily air mass classification by means of statistical analyses based on ground meteorological data was carried out. A comparison between air mass classification and hospital admissions was made by the calculation of a MI admission index, and to detect significant relationships the Mann–Whitney \textit{U} test, the analysis of variance, and the Bonferroni test were used. Significant increases in hospital admissions for MI were evident 24 h after a day characterized by an anticyclonic continental air mass and 6 days after a day characterized by a cyclonic air mass. Increased risk of hospitalization was found even when specific 2-day air mass sequences occurred. These results represent an important step in identifying reliable linkages between weather and health.

Keywords: Weather type; Myocardial infarction; Anticyclonic; Cyclonic; Time lag

1. Introduction

There is much epidemiological evidence that cold weather conditions could represent aggravating circumstances or trigger factors for cardiovascular diseases, in particular for myocardial infarction (MI). Seventy years ago, Masters et al. (1937) already showed an increase in mortality due to MI in the United States during the winter months. More recently, the peak of coronary death and the winter increase in hospital admission rates for MI have been related to the effects of low temperature (Thakur et al., 1987; Marchant et al., 1993; Spencer et al., 1998). A multicenter European survey (Eurowinter Group, 1997) showed that the percentage increase in ischemic heart disease mortality was greater with a fall in air temperature, mainly in populations located in regions at lower latitude (with mild winters) and for people who lived in cooler homes, wore fewer clothes, and were less active outdoors. Findings concerning a large longitudinal study performed in France (Danet et al., 1999) showed that a 10 °C decrease in air temperature was associated with 13% increase in total coronary event rates and 11% increase in incident and coronary death rates.

Relationships between weather conditions and hospital admissions have been so far investigated through different approaches: (a) by using a single meteorological variable.
(generally air temperature), treating weather as a univariate phenomenon (Marchant et al., 1993; Danet et al., 1999); (b) by considering the combined effects of several meteorological parameters, treating weather as a bivariate phenomenon (usually air temperature and relative humidity or wind speed) using simple biometeorological indices (Rusticucci et al., 2002; Panagiotakos et al., 2004; Morabito et al., 2005) or multivariate phenomenon by means of thermophysiological models based on the human energy balance (Morabito et al., 2004); or (c) by a synoptic climatological approach, described as either "weather types" (synoptic events categorized by pressure patterns and wind fields) or "air masses" (based on a wider variety of ground weather elements). The first two approaches are limited by considering only one or more ground meteorological parameters and cannot describe the simultaneous action of the weather complex. On the other hand, the synoptic climatological approach allows the classification of weather patterns into categories (Sheridan, 2002) that are expressions of the weather conditions at a particular location, which can be used to evaluate the potential synergistic impacts of an entire suite of weather elements on environmental and biological parameters sensitive to weather (Barry and Perry, 1973).

The synoptic climatological classification can be divided into two kinds of procedures: (1) manual classification and (2) automated classification. The first procedure involves the subjective classification of circulation patterns from visual analyses of individual synoptic maps. This classification has the drawback that it is "not replicable" (El-Kadi and Smithson, 1986; Yarnal, 1993) and different researchers will not necessarily agree on a classification for a given day. Alternatively, an automated procedure is an objective analysis applied to meteorological data, generally provided by one weather station and elaborated by statistical analyses. This procedure is generally "reproducible" (Yarnal, 1993) and principal component and cluster analyses represent the main applied statistical methods (Kalkstein and Corrigan, 1986; McGregor, 2001).

Several epidemiological studies employed these classifications to evaluate the impact of weather conditions on mortality events (Kalkstein, 1991; Kalkstein and Greene, 1997; McGregor, 2001), while only a few researchers have studied the impact on hospital admissions, generally for respiratory diseases (Jamason et al., 1997; McGregor et al., 1999).

The aim of the present study was to investigate the winter risk of hospitalization for MI in the Florentine area (central Italy) by means of daily weather conditions, classified by an air-mass-based synoptic climatological approach, even detecting a possible time-lag phenomenon and considering the effects of 2-day sequences with specific air mass types. A winter-only analysis is presented in this study because winter, together with autumn, is the season characterized by the highest mean MI admission rate in the study area.

2. Materials and methods

2.1. Meteorological data

Meteorological data measured at 0900 and 1500 h were provided for the winter months (December to February), from 1998 to 2003, by the Institute of Biometeorology of the National Research Council, which manages a weather station located in Florence (i = 11°11'E; Φ = 43°47'N). Seven meteorological variables were considered: (1) dry bulb temperature; (2) cloud cover; (3) saturation deficit; (4) atmospheric pressure; (5) wind speed; (6) u (West-East) component of the wind, assessed by the sine transformations of wind speed and direction; and (7) v (North-South) component of the wind, assessed by the cosine transformations of wind speed and direction. These variables are considered to be good indicators of air mass characteristics (McGregor et al., 1999).

2.2. Hospital discharge data

Computerized inpatient hospital discharge data for MI (808 hospitalizations) over the five-winter survey were provided by the Administration of Careggi Hospital (source: Azienda Ospedaliera di Careggi–Firenze), the main hospital in Tuscany. Only data of people resident in the Florentine area were considered. Patients with primary discharge diagnosis with codes from 410 to 410.92 (ICD-9-CM) were selected.

2.3. Daily air mass type classification

The objective method to classify daily air mass type was performed by using two statistical packages: SPSS for Windows version 10.0 (SPSS, Inc., 1998) and XLSTAT version 7.1. (www.xlstat.com). Principal components analysis (PCA) and the following agglomerative hierarchical clustering (AHC) were used to identify groups of days for which the covariant behavior of meteorological variables was similar. All days characterized by a wind speed value lower than 0.2 m s\(^{-1}\) at both 0900 and 1500 h were considered as calm days and the wind direction was excluded by the analysis. The statistical procedure adopted in this study followed that employed in other studies (McGregor et al., 1999; Kalkstein, 1991; Kalkstein et al., 1987; Yarnal, 1993) and groups of days with similar meteorological characteristics were identified. The application of the scree method allowed the identification of four PCA which accounted for 74.2% of the variance in the original meteorological data. The percentage of variance explained by each PCA is PCA1 \(= 30.8\%\), PCA2 \(= 21.4\%\), PCA3 \(= 13.1\%\), and PCA4 \(= 8.9\%\). By using these four PCA scores as input variables for the AHC, five air mass types were identified. In order to characterize each winter air mass type, correspondent median, quartile, and extreme values of daily original meteorological variables were calculated (data not shown).

The synoptic and meteorological characteristics of the five winter air masses identified are:

1. Anticyclonic polar continental (air mass type 1): simultaneous presence of an anticyclonic center over northern and central Europe and a cyclonic center over the Balkans and central Mediterranean sea. Such synoptic situation is generally characterized by strong and relatively dry northeasterly, easterly winds and induces cold air advection.
2. Anticyclonic continental (air mass type 2) (Fig. 1a): a well-developed anticyclonic system dominates the central Mediterranean sea, having its center on central Europe. It is the coldest air mass, with clear sky, high atmospheric pressures, and very feeble winds.
3. Anticyclonic mixed tropical maritime and continental (air mass type 3): this situation can be the result of the development of an anticyclonic gloop over northern Africa or the possible temporal evolution of the synoptic situation described for air mass type 2. It is
2.4. Analysis of hospital admissions for myocardial infarction

An exploratory analysis to detect the relationship between hospital admissions for MI and days of the week was preliminarily carried out. This first analysis and the following main analysis of comparison between air mass type classification and hospital admissions for MI were made by the calculation of a myocardial infarction admission index (MIAI) (Eq. (1)), following the approach proposed by McGregor et al. (1999):

\[
MIAI(i) = \frac{\text{Hospital admissions (i)}}{\text{Winter average admission (y)}} \times 100, \tag{1}
\]

where (i) and (y) represent a specific day and year, respectively. Daily MIAI were calculated taking into consideration the average admission value characteristic of each winter. A MIAI of 200 means that the admissions for MI are 2.0 times that of the average winter. To detect the possible time lag between exposure to weather conditions and onset of disease the comparisons were carried out considering hospitalizations on the current day of each weather type (lag = 0) up to admissions that occurred on the following days (lag = 1, 2, 3, ..., 7). The statistical distribution of hospital admissions for MI followed a Poisson distribution ($\chi^2$ goodness of fit test), but MIAI distribution did not satisfy the exponential (Kolmogorov–Smirnov test) and the normality distribution (Shapiro–Wilk normality test). For this reason and because of the small sample size, days of the week and air mass types were tested for MIAI differences using a nonparametric procedure, the Mann–Whitney $U$ test.

Two-day sequences of air mass types (air mass on day$_{i-1}$ and air mass on day$_i$) were also investigated, and each possible 2-day air mass combination (25 potential combinations with five air masses) with the MIAI referring to the last day of the sequence (on day$_i$) was then identified. With the aim of solving the problem of having small numbers of some observed 2-day sequences, a block bootstrap method for time series (Davison and Hinkley, 1997) was applied by using the “boot” R package (Ihaka and Gentleman, 1996). Two-day sequences of air mass types were then tested for MIAI differences by using analysis of variance (ANOVA) and the Bonferroni test.

3. Results

The distribution of hospital admissions for MI over the 5 years studied (Table 2) showed a significant linear increase going from the winter of 1998–1999 to the winter of 2002–2003 ($P<0.001$). The highest number of hospitalizations was observed in the last winter (2002–2003), about double in comparison to the first.

The exploratory analysis showed higher MIAI values going from Tuesday to Thursday and lower values during the weekend (Fig. 2). The Mann–Whitney $U$ test showed significant differences between MIAI values on Saturday (lowest MIAI values) and those observed on Tuesday ($P<0.05$), Wednesday ($P<0.01$), and Thursday ($P<0.01$), when the highest mean MIAI value was found (Fig. 2).

Regarding the relationship between the risk of hospital admission for MI and daily weather conditions, the descriptive statistics (Table 3) showed that when the mixed air mass occurred the mean MIAI on the same day (lag = 0) and on following days (lag = 1, 2, 3, ..., 7) was always below 100, which means that hospitalizations were below those of the average winter. Even when the anticyclonic polar continental air mass occurred the mean MIAI was below 100, with the only exception of hospitalizations occurring 3 days later (lag = 3) (Table 3). Conversely, the other two anticyclonic air masses were characterized by high atmospheric pressures and generally weak winds with prevalent southwesterly directional types, which favor increases in air temperature and even high humidity levels.

(4) Cyclonic (air mass type 4) (Fig. 1b): associated with frontal passages which often induce the formation of a cyclonic system centered on the central Mediterranean sea. Days are cloudy, with the lowest atmospheric pressure values; high humidity levels; variable wind regime, predominantly southwesterly; and mild air temperature.

(5) Mixed (air mass type 5): not easily attributable to specific synoptic situations such as the previously mentioned air masses. All situations are characterized by low pressure gradient over the central Mediterranean sea and sometimes by passages of feeble fronts. It is characterized by high humidity levels, low winds, and high cloud cover and sometimes characterized by feeble fronts from the south or southwest with mild air temperature.

The $\chi^2$ test for the frequency distribution of air mass types over time showed a statistically significant variability, with the only exception being the winter of 1998–1999 (Table 1). Air mass type 5 usually showed the maximum frequency, while the minimum was observed for air mass type 2 (Table 1). The latter showed the lowest frequency value (1.1%) during the winter of 2000–2001, which means only 1 day with this air mass.
masses (continental; mixed tropical maritime and continental) and the cyclonic ones often showed, on the same day and on following days, mean MIAI values above 100, which means that hospitalizations were above those of the average winter. The Mann–Whitney $U$ test showed significant MIAI differences between air masses over short

### Table 1
The $\chi^2$ test for the frequency distribution of air mass types over time

<table>
<thead>
<tr>
<th>Winter</th>
<th>Anticyclonic</th>
<th>Cyclonic (%)</th>
<th>Mixed (%)</th>
<th>$\chi^2$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar continental (%)</td>
<td>20.0</td>
<td>17.8</td>
<td>21.1</td>
<td>21.1</td>
<td>20.0</td>
</tr>
<tr>
<td>Continental (%)</td>
<td>8.8</td>
<td>13.2</td>
<td>24.2</td>
<td>17.5</td>
<td>36.3</td>
</tr>
<tr>
<td>Mixed tropical maritime and continental (%)</td>
<td>22.2</td>
<td>1.1</td>
<td>18.9</td>
<td>15.6</td>
<td>42.2</td>
</tr>
<tr>
<td>All winters</td>
<td>13.3</td>
<td>6.7</td>
<td>13.3</td>
<td>23.3</td>
<td>24.5</td>
</tr>
</tbody>
</table>

### Table 2
Distribution of hospital admissions for myocardial infarction (MI) during winter over the 5 years studied

<table>
<thead>
<tr>
<th>Winter</th>
<th>Winter admissions for MI</th>
<th>Winter admissions for MI</th>
<th>Winter admissions for MI</th>
<th>Winter admissions for MI</th>
<th>Winter admissions for MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998–1999</td>
<td>Total number (daily average ± SD)</td>
<td>Total number (daily average ± SD)</td>
<td>Total number (daily average ± SD)</td>
<td>Total number (daily average ± SD)</td>
<td>Total number (daily average ± SD)</td>
</tr>
<tr>
<td>Subjects ≥ 65 years</td>
<td>86 (1.0 ± 0.9)</td>
<td>99 (1.1 ± 1.1)</td>
<td>119 (1.3 ± 1.2)</td>
<td>122 (1.4 ± 1.2)</td>
<td>140 (1.6 ± 1.3)</td>
</tr>
<tr>
<td>Subjects &lt; 65 years</td>
<td>29 (0.3 ± 0.6)</td>
<td>41 (0.5 ± 0.6)</td>
<td>49 (0.5 ± 0.8)</td>
<td>50 (0.6 ± 0.8)</td>
<td>73 (0.8 ± 0.9)</td>
</tr>
<tr>
<td>All subjects</td>
<td>115 (1.3 ± 1.0)</td>
<td>140 (1.5 ± 1.3)</td>
<td>168 (1.9 ± 1.5)</td>
<td>172 (1.9 ± 1.5)</td>
<td>213 (2.4 ± 1.7)</td>
</tr>
</tbody>
</table>

The daily average number of hospital admissions for MI and standard deviation (± SD) are indicated in parentheses.

![Fig. 2](image-url)  
Fig. 2. The mean myocardial infarction admission index (MIAI) depending on days of the week. The 95% confidence intervals for average MIAI are indicated in parentheses. A MIAI value of 100 (dashed line) indicates the average level of winter admissions.
The 95% confidence intervals for average MIAI are indicated in parentheses. A MIAI value of 100 indicates an average winter level of admissions.

and long periods. In the first case MIAI values occurring 24 h (lag = 1) after a day characterized by an anticyclonic continental air mass were statistically higher than MIAI values occurring the day after a mixed air mass ($P < 0.05$). MIAI values above the average winter over short periods were found even considering the anticyclonic mixed tropical maritime and continental air mass and the cyclonic ones (Table 3); nevertheless, no statistical differences from other air masses were observed. Regarding significant differences over long periods, MIAI values occurring 6 days after a cyclonic air mass were significantly higher than MIAI values occurring 6 days after an anticyclonic polar continental ($P < 0.05$) or after a mixed ($P < 0.05$) air mass.

Regarding the investigation of all possible 2-day sequences of air mass types (Table 4), 14 combinations showed MIAI levels on the last day of the sequence above the average winter (MIAI > 100) and 11 combinations showed MIAI values below the average winter (MIAI < 100). The ANOVA showed significant variations ($P < 0.001$) of mean MIAI values among all possible 2-day sequences of air masses. Among daily sequences producing MIAI > 100, the combination with the highest frequency ($16.5\%$) was found when a 2-day combination with the mixed air mass type occurred (day$_{-1}$ = air mass type 4 and day$_0$ = air mass type 5). The combination day$_{-1}$ = air mass type 1 and day$_0$ = air mass type 4), air mass type 3 (day$_{-1}$ = air mass type 3 and day$_0$ = air mass type 4), and air mass type 2 (day$_{-1}$ = air mass type 4 and day$_0$ = air mass type 2), but never with air mass type 5 (Table 4). The cyclonic air mass was the most frequent in all 2-day combinations producing MIAI above those of the average winter.

Among daily sequences of air mass types producing MIAI values below those of the average winter, most 2-day combinations involved air mass type 5, and the highest frequency ($16.5\%$) was found when a 2-day combination with the mixed air mass type occurred (day$_{-1}$ = air mass type 5 and day$_0$ = air mass type 5). The combination day$_{-1}$ = air mass type 1 and day$_0$ = air mass type 5 (which is a cold dry and windy day followed by a humid and mild day) showed the lowest mean MIAI value (MIAI = 56) and the Bonferroni test showed a significantly (from $P < 0.01$ to $< 0.001$) lower mean MIAI than those observed when the other 2-day combinations occurred.

4. Discussion

The present study has shown that hospital admissions for MI in Florence are closely related to specific weather patterns.

The main findings of this study are:

(1) Significant relationships between specific weather conditions and hospital admissions for MI were evident over short and long periods:

- the risk of hospital admissions for MI occurring 24 h after a day characterized by an anticyclonic continental air mass was significantly higher than the risk of hospitalization observed 24 h after a day with a mixed air mass (25% increase in admissions) and
- the risk of hospital admissions for MI occurring 6 days after a day characterized by a cyclonic air mass was significantly higher than the risk of hospitalization observed 6 days after a day with an
anticyclonic polar continental (15% increase in admissions) or a day with a mixed air mass (12% increase in admissions).

(2) Two-day sequences which showed high frequencies (above 5% of relative frequency) of hospitalizations above those of the average winter were represented by two different situations:

- a day characterized by an anticyclonic mixed tropical maritime and continental air mass followed by a day with a mixed air mass and
- two consecutive days characterized by the persistence of the same air mass, cyclonic, anticyclonic mixed tropical maritime and continental, or anticlyclic continental.

(3) Two-day sequences which showed the highest increases in hospitalizations above the average winter, but with low frequencies, can be attributed to two specific day-by-day changes of weather patterns:

- a very cold day characterized by an anticyclonic continental air mass followed by a blustery day with an anticyclonic polar continental air mass and
- sequences of days with a rapid alternation of anticyclonic and cyclonic air masses, which are characterized by sudden changes of atmospheric pressure, humidity, and cloud cover.

(4) Most 2-day sequences with low risk of hospitalization for MI (below that of the average winter) involved the mild mixed air mass type, which is the most frequent in the studied winters in the Florentine area.

The air-mass-based synoptic climatological approach used in this research shows a wide applicability in the analysis of the potential effect of weather on human health. In a recent study (Kassomenos et al., 2001), a weather classification of air masses was recognized as a useful tool for studying the weather–health associations in a warm Mediterranean climate.

The short-term effect of cold weather on hospital admissions for MI confirms the results obtained in a study (Morabito et al., 2005) in which a biometeorological index (which combines air temperature and wind speed) was used and the effects caused by severe discomfort for several hours of exposure to cold were visible up to 2 days. In another study (Schwartz et al., 2004), carried out in the United States, the authors found that the effects of daily average temperature on hospital admissions for heart disease predominantly occurred within a few days after exposure.

The interpretation of the long-term effect (lag = 6) is unclear and previous studies did not show similar results. It

<table>
<thead>
<tr>
<th>2-day air mass type sequence</th>
<th>Absolute frequency of 2-day sequences</th>
<th>Relative frequency of 2-day sequences (%)</th>
<th>Average MIAI</th>
<th>95% confidence interval for average MIAI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day-1 Day0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2  1</td>
<td>506</td>
<td>1.1</td>
<td>172</td>
<td>164 to 180</td>
</tr>
<tr>
<td>1  4</td>
<td>659</td>
<td>1.5</td>
<td>160</td>
<td>155 to 166</td>
</tr>
<tr>
<td>2  4</td>
<td>897</td>
<td>2.0</td>
<td>154</td>
<td>146 to 163</td>
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<td>574</td>
<td>1.3</td>
<td>152</td>
<td>148 to 156</td>
</tr>
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<td>2410</td>
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<td>134</td>
<td>130 to 137</td>
</tr>
<tr>
<td>3  3</td>
<td>2592</td>
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<td>121</td>
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<tr>
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<td>92 to 97</td>
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<td>2265</td>
<td>5.1</td>
<td>71</td>
<td>68 to 74</td>
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<tr>
<td>5  5</td>
<td>7373</td>
<td>16.5</td>
<td>69</td>
<td>67 to 70</td>
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<tr>
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<td>2592</td>
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<td>66</td>
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<td>58 to 66</td>
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<td>1497</td>
<td>3.4</td>
<td>60</td>
<td>57 to 63</td>
</tr>
<tr>
<td>1  5</td>
<td>1484</td>
<td>3.3</td>
<td>56</td>
<td>52 to 59</td>
</tr>
</tbody>
</table>

Rows ordered by average MIAI.
is most likely that other factors rather than meteorological effects might play an important role contributing to the occurrence of MI. MI frequency has often been shown to peak on Mondays (Willich et al., 1994; Spielberg et al., 1996; Kinjo et al., 2003) and this may be due more to environmental work/play influences (Zipes, 1999). Recently, other authors (Barnett et al., 2004) have shown that this peak is probably an artifact, resulting from a tendency to record cases with unknown onset on Monday. In contrast, the present study did not show a peak of MI on Mondays, but showed that hospital admissions significantly increased starting from Tuesday and reached the maximum on Thursday, supporting the hypothesis of the influence of accumulated stress during working days.

In addition, the associations between hospital admissions for MI and weather conditions may be biased by other health complications such as respiratory infections, viral and bacterial, which may trigger attacks of coronary heart disease. Clinical studies showed that many acute MI in winter are preceded by an upper respiratory tract infection (Spodick et al., 1984; Meier et al., 1998). In particular influenza has been associated with an increased risk of coronary heart disease in previous studies (Bainton et al., 1978; Spencer et al., 1998), and epidemiological studies have shown a 7- to 10-day lag in the development of cardiovascular disease outcomes after influenza in individual patients (Giezen et al., 1982; Madjid et al., 2004).

In the present study, specific combinations of air masses with day-by-day substantial changes in weather patterns or the persistence of the same air mass type over Florence for 2 consecutive days (in particular the cyclonic, the anticyclonic continental, or the anticyclonic mixed tropical maritime and continental air mass) were clearly associated with hospitalizations for MI above those of the average winter. These findings have also been confirmed by other authors. In a study on the short-term effects of atmospheric circulation types on mortality (Kassomenos et al., 2001) the highest relative risk of winter mortality in Athens (Greece) was attributed to the weather type characterized by easterly winds. This finding was also found in the present study regarding Florence, still in the Mediterranean basin, but relative to hospitalizations for MI, in particular when a very cold and calm day occurred, characterized by clear sky and high humidity level especially during night, when haze, fog, and the thermal inversion phenomenon can also occur (anticyclonic continental air mass), followed by blustery days, with strong and dry northeasterly or easterly winds and cold air advection (anticyclonic polar continental air mass). Kassomenos et al. (2001) even found that a very weak southerly flow was associated with elevated risks of winter mortality. This southerly wind with low intensity carries moist air masses from the sea and greatly increases the relative humidity. This is also associated with a relative increase (for the season) in air temperature and creates unpleasant weather conditions (Kassomenos et al., 2001). Such phenomenon is very similar to that observed over the Florentine area when 2-day sequences involved the anticyclonic mixed tropical maritime and continental air mass type. McGregor (2001) found that the persistence of certain air mass types over northern Europe (Birmingham, UK), especially a cold polar continental air mass (with strong northeasterly to southeasterly flows of cold air, which bring rapidly changing and anomalous thermal conditions to the study area) and a moderately warm blustery maritime air mass (with blustery flows from the west and rapidly changing weather), were significantly associated with an increase in mortality for ischemic heart disease.

In the literature there are many descriptions of the effects of low temperature on cardiovascular diseases (Mercer, 2003) and several explanatory mechanisms have been suggested. Cold-induced vasoconstriction causes a significant increase in arterial pressure and heart workload (Keatinge et al., 1984) that could result in myocardial ischemia in patients with coronary diseases (Dubois-Rande et al., 1995). It has been proposed that higher fibrinogen activity in winter might be a possible cause that contributes to an increase in the occurrence of cardiovascular diseases in winter (Stout and Crawford, 1991; Woodhouse et al., 1994). Nevertheless, the detailed mechanisms by which cold influences the pathogenesis of cardiovascular diseases, directly or via respiratory infections, have not been clarified (Nayaha, 2002).

In Florence, even sudden changes in atmospheric pressure, associated with substantial variation of air temperature, humidity, and cloud cover, caused by rapid alternation of anticyclonic and cyclonic air masses, were related to a considerable increase in hospitalizations for MI. In a study carried out in Pilsen (Czechoslovakia) (Kveton, 1991) the author showed an increase in MI occurrence concomitant with particular types of weather fronts, especially taking into consideration the time interval demarcated by the passage of fronts and the types of the foregoing and the subsequent front. A recent study in several American cities (Ebi et al., 2004) evidenced that rapid weather changes, classified by considering daily maximum and minimum temperature changes, resulted in increased hospitalizations for MI of elderly people by 6–13%. Such short-term meteorological variations have been reported to cause physiological and biochemical processes. For example, changes in blood viscosity and clotting time occurred with the passage of major fronts (Curson, 1996).

Our findings also show that an accurate analysis needed to take into consideration the simultaneous and complex combination of weather variables. While dry-bulb and dew-point temperatures are traditionally considered in epidemiological studies to analyze the relationships between weather and health, other atmospheric variables (i.e., wind, atmospheric pressure, and large-scale circulation patterns) are not. Even when several meteorological variables are considered, they are often treated as univariate or at most as bivariate.
This study has necessarily been exploratory in nature because it is based on a limited number of hospital admissions for MI from only five winters and no age and gender differences were considered. Furthermore, this study is also limited to one geographical area and therefore the results may not be extended at a larger geographical scale. These limitations should encourage further studies using the air-mass-based synoptic climatological approach, even taking into consideration simultaneous effects of other environmental variables, such as pollutants and pollen. It will be necessary to extend this analysis over a longer period and on larger localities, increasing the sample and taking into consideration other human factors, such as age and gender.

All these further steps will be indispensable to identify reliable linkages among weather, air quality, and health, in order to develop an exhaustive synoptic climatological model useful for daily management of hospital resources and to improve hospital assistance.

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