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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 *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

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(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, 1992; 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 ($\lambda = 11°1'E$; $\Phi = 43°47'N$). 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 values 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 gloom over northern Africa or the possible temporal evolution of the synoptic situation described for air mass type 2. It is