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MONTHLY MORTALITY CHANGES RELATED TO TEMPERATURE IN BAHÍA BLANCA, ARGENTINA

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ABSTRACT

This paper examines the monthly mortality rates related to mean monthly temperatures in Bahía Blanca city, located in the southwestern region of the Buenos Aires province, Argentina. Bahía Blanca is a typical temperate mid-latitude city with a population of 300,000. The 5 year period, 1988 to 1993, was analysed. Mortality data were supplied by the Sanitarian Region I of the Argentine Health and Social Action Service. Mean monthly temperatures for Bahía Blanca were obtained for the same period from a station run by the Argentine Meteorological Service located inside the city. Standard statistical methods were used to examine the meteorological and mortality information. Data indicated that the primary meteorological correlation for the monthly variation in mortality is the outdoor temperature. A correlation was found between the mean monthly temperature and the mortality rates, and the mortality rates appears to be further affected by the individual month temperatures deviations from their respective long-ranging mean.
Keywords: mortality rate, biometeorology, air temperature, Bahía Blanca.

RESUMEN

Este trabajo examina la relación existente entre la mortalidad y las temperaturas medias mensuales de la ciudad de Bahía Blanca, localizada en el Sudoeste de la provincia de Buenos Aires, Argentina. Bahía Blanca es una típica ciudad de clima templado de latitudes medias con una población de 300.000 habitantes. Se analizó un período de cinco años, 1988-1993. Los datos de mortalidad fueron proporcionados por la Región Sanitaria I del Ministerio de Salud de la Provincia de Buenos Aires. Los datos meteorológicos fueron obtenidos de una estación perteneciente al Servicio Meteorológico Nacional localizado en la misma ciudad. Se utilizaron métodos estadísticos estándar para estudiar la información meteorológica y de mortalidad. Los datos indican que la temperatura del aire sería un factor significativo para explicar la variación de la mortalidad. Se encontró una correlación entre la temperatura media mensual y la mortalidad mensual. Además las anomalías de la temperatura mensual podrían ser un elemento que explique en parte las variaciones en la mortalidad mensual.
Palabras claves: mortalidad, biometeorología, temperatura del aire, Bahía Blanca.

1. INTRODUCTION

Biometeorology deals with the identification of the relationship between a biological response and atmospheric events. Climatic stress on humans depends on a large number of variables both in the environment and in the individual human. This type of stress is associated with a persons metabolic rate, ability to perspire, weight and age. Temperature is the most significant meteorological parameter to take into account when studying climatic stress. The environmental factor of concern are maximum and minimum temperature, more specifically, its sudden temperature changes, humidity and wind speed. Previous

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experiments indicate that the exposure to unfavourable temperatures leads directly to death (Landsberg, 1981).

Research on the effects of meteorological variables on mortality has been very intense in the last three decades. Some of this research has been in Japan, where Cech and Momiyama have studied the effects of weather on mortality in their regions for decades (Binkley,1998). Research has been also performed in other countries as well. Keatinge *et al.* (1989) have observed variations in seasonal mortality of people in Wales, England and they analysed causal factors. They conclude that brief excursion outdoors by people aged 70-74 rather than low temperatures indoors were the causes of mortality in winter. Tanaka and Tokudome (1991) found a relationship between hypothermia and death from cold in urban areas which is correlated with males in their forties and fifties. They detect that 84% of urban hypothermia cases occurred when the outdoor temperature was below 5°C, and 50% of death from cold occurred when the outdoor temperature was between 0°C to 5°C. The number of heart attack and other forms of cardiovascular death varies systematically with air temperature over time scales between daily and seasonal periods. Frost *et al.* (1998) examined rates of heart attack death in those over age 65 in four urban Canadian environments with different thermal climates and found that the highest death rates occurred close to the warmest and coldest temperatures regardless of absolute temperature values. It has been shown that in The Netherlands, all cause of mortality, has a bimodal peak in the first month of the year, after which it declines to reach a plateau in late spring (Mackenbach *et al.*, 1992). In that country mortality is lowest at the end of August, after which it rises steeply again. This winter excess peak of all cause of mortality is due primarily to cardiovascular diseases (66%) and respiratory conditions (13%).

In the literature a great deal of work can be found on the subject (i.e., Bridger and Helfhand, 1968; Truppi, 1983; Keatinge, 1986; Piccolo *et al.*, 1988; Kunst *et al.*, 1991; Tan, 1991; Yao *et al.*, 1991). However there are not too many works done in South America and particularly in Bahía Blanca, Argentina.

To the author´s knowledge only one study has been done in the association between the weather and illness in Bahía Blanca (Piccolo *et al.*, 1988) and a few related to the relationship between weather conditions and mortality where only cold or warm temperature episodes were correlated with human death (Capelli *et al.*, 1995; Capelli *et al.*, 1997; Capelli *et al.*, 1997). Therefore, the objective of the present investigation is to describe the monthly changes in mortality in Bahía Blanca and to find the role of the temperature in this changes.

2. BAHÍA BLANCA CITY

Bahía Blanca (38°44' S - 62°10'W) is situated on the southwest of the Buenos Aires province, Argentina (figure 1). It is a typical temperate midlatitude city which grew from a small military emplacement established in 1828 in his vast plain near the Atlantic Ocean, and at the margins of the *Napostá* stream. Currently it is a typical city with different build-up areas. A central square is bounded by multi-story buildings. The total population of the Bahía Blanca and suburban centres is of about 300,000, a medium-sized city in Argentina. The city is free from orographic effects, however, the Napostá escarpment divides the city

into two levels whose altitudes differ 70 m. The lower level is situated along the Bahía Blanca estuary and it encompasses the industrial activities, including a chemical, an electrical, a harbor and several fisheries. Ingeniero. White (figure 1) is 10 km from the city. It concentrates the grain companies and has a fishing port. The central district, at about 25 m above sea level, contains the commercial and business areas. The upper level of the city is rapidly developing; it is a commercial and residential (Palihue, Patagonia neighbourhoods, figure 1) area where new shopping sectors have been established in the last several years. Nearby are the civil airport and a Military Base. Bahía Blanca is a very important educational centre; the Universidad Nacional del Sur is one of the most notables universities in the country. The surrounding area of the city is cultivated land, a rural area.

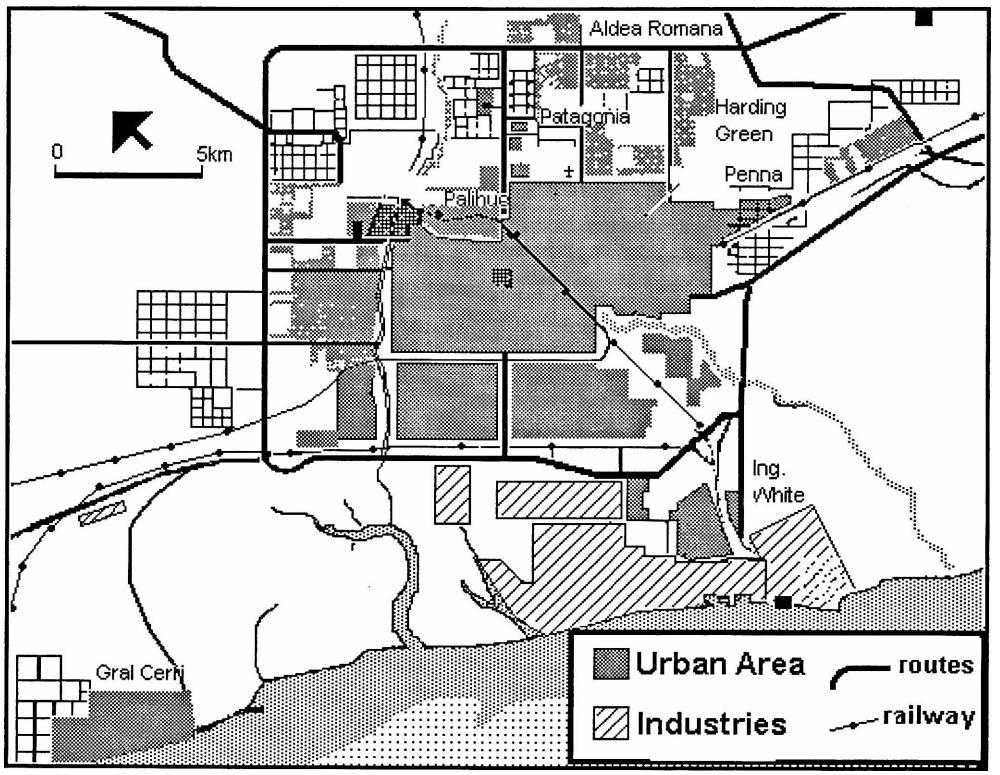

Figure 1. The Bahía Blanca city and its urban neighbourhoods (38°44' S - 62°10' W)

The climate of Bahía Blanca is continental in character with some modification due to its proximity to the sea. Winters and summers are well defined; the former has an average temperature of about 8°C and the latter around 22°C. The annual precipitation is 700 mm. It is high in spring and summer but it is insufficient in autumn and winter. The city is a very windy one. The prevailing winds are from the NW, N and SW. Annual mean velocity is about 20-25 km/h and it increases in the warm season. Frequently the disturbed weathers turn the daily conditions very uncomfortable, especially when dust is present (Capelli and Campo, 1994). The gusts reach values of 100 km/h.

In order to contribute to the study of urban climates in middle latitudes, the urban heat island was closely analysed in Bahía Blanca city. The heat island is a phenomenon derived from anthropogenic effects on the environment related to land use patterns. The results showed that the city generates a heat island both in summer and winter. On February, at the time of highest temperature (16 h), the city is cooler than the suburban areas with small or more widely separated buildings. Some distinct cells of fresh air are evident on the wooded parks which present the minimum value. At 20 h the nocturnal heat island is well developed in the city. The temperature near the central square is warmer that in its immediate surrounding and the intensity of the heat island is 7°C (Capelli *et al.*, 1985, Piccolo and Capelli de Steffens, 1985)

The heat island in winter presents some pattern differences. During the day there is not a significant heat island only a warm and small cell of 1°C appearing in the central area. At night the situation is different with the intensity of the heat island being 6°C. In spite the proximity to the sea, the city has a dry climate. There are small humidity spatial differences inside the city in all the seasons (about 20% in the day and only 10% at night) (Piccolo and Capelli de Steffens, 1987).

The comfort has been also studied in Bahía Blanca (Capelli *et al.*, 1991). The comparison between different comfort indexes determined that the Bahía Blanca population is under severe discomfort conditions when air temperature rises 36°C and relative humidity is about 50%. These conditions are meet frequently in the summer season when in some cases the temperature reaches 42°C. In those situations all outdoors activities should be stopped.

3. METHODOLOGY

Daily death data were supplied by the Sanitarian Region I of the Argentine Health and Social Action Service and were codified according the International Statistical Classification of Diseases and related Health Problems (1992), for the period 1988-1993. The information was also classified by age and sex. Meteorological data was obtained for the same period from a station located inside of the city. Mean temperatures for the same city was obtained by the Argentine Meteorological Service.

Descriptive statistical methods were applied to analyse the data. The methodology used in this paper was taken from Roenneberg and Aschoff (1990) and Lerchl (1998). The mortality data was expressed in two ways as a whole number and as per cent above and below the monthly mean (0%). Regression analysis was applied to find a possible relationship between the average monthly temperature and the corresponding mortality rates.

4. RESULTS AND DISCUSSION

The analysis of the annual mortality rate in the city showed an average of 2231.8, that means that the city has a mean daily mortality of 6 persons. The percentage mortality rate above and below the mean for each year of the study period is presented in figure 2. This variable does not behave in the same manner every year, although there are some features

in common that will be discussed later. Some years present monthly mortality rates well above the monthly mean as in July 1988, May 1992 and June 1993. Others month, as March though August 1989 and April trough August 1991, show values below the monthly mean.

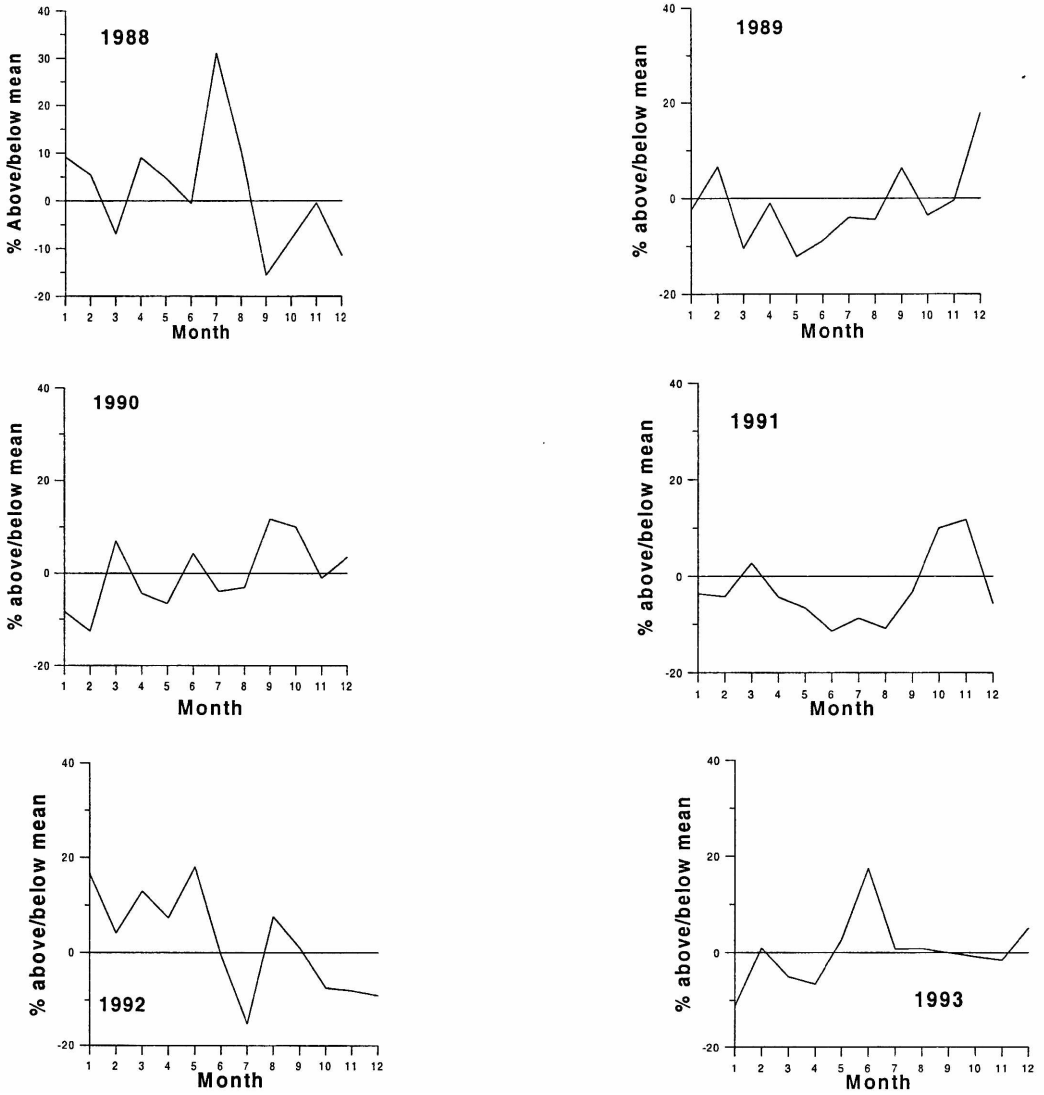

Figure 2. Monthly variation of mortality rate for the period 1988-1993.

If the anomalies of the mean monthly temperatures are analysed (figure 3) the year 1988 showed negative anomalies and 1992 presents the greatest positive and negatives ones. The maximum positive mortality rates, were registered in July 1988 with 31.01%

above normal, followed by values of 17.37 and 17.96% in May 1992 and June 1993, respectively. Mortality rates of 17.71% and 16.63% were found in December 1989 and January 1992, respectively. In the winter of 1988 the mean temperature was 5.3°C, this value was well below normal (7.2°C) because absolute minimum temperatures reached values of -11.7°C, with mean minimum temperatures of -1.2°C. The July mean minimum temperature for the city is 2.6°C. This fact explains the extreme mortality rate of the month of July.

To complete the meteorological comparison, figure 4 shows the relationship between the % of mortality above/below normal and the deviation of the monthly mean temperature from the average for the six years in study. In 1989 the mortality rates were mostly below normal because the temperatures were above normal most of the year. There is some correlation between temperature deviation from mean conditions and mortality rates. In general when de monthly temperatures are below normal the mortality rates increases.

Further analyses of the relationship between mortality rates and mean temperatures were completed studding the mortality rate associated with the deviation of the monthly temperatures (T_m) with the climatological means (figure 4). During the study period 51 % of the T_m was between -1 and +1. However, more percentage is found when T_m is positive. Regression analysis was performed between monthly mortality and mean monthly temperatures. Figure 5 shows the regression curve with the 95 % confidence intervals. The regression coefficient was 0.65 (p<0000001). Therefore, some correlation was found between those variables.

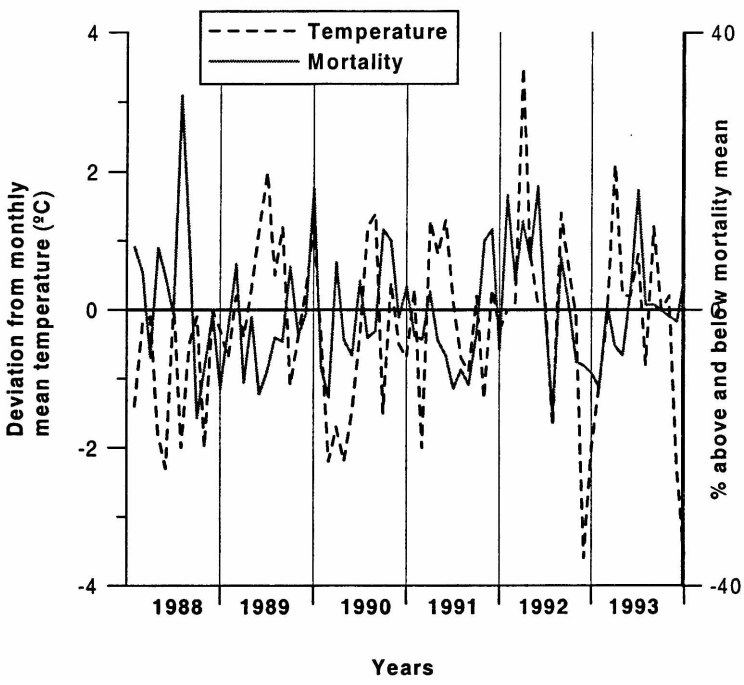

Figure 3. Deviation from mean monthly temperature related to mortality rate.

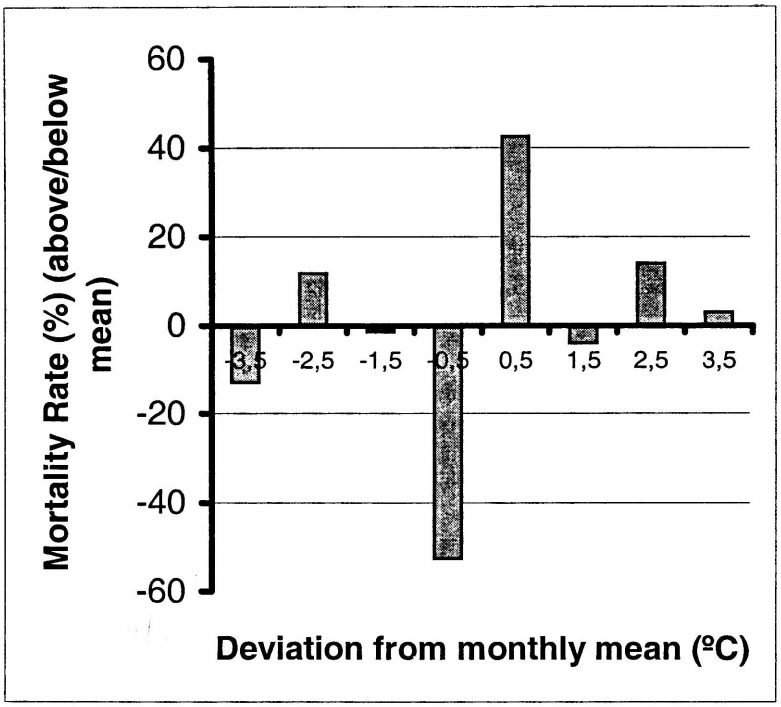

Figure 4. Effects of deviations of the mean temperatures on the mortality rates.

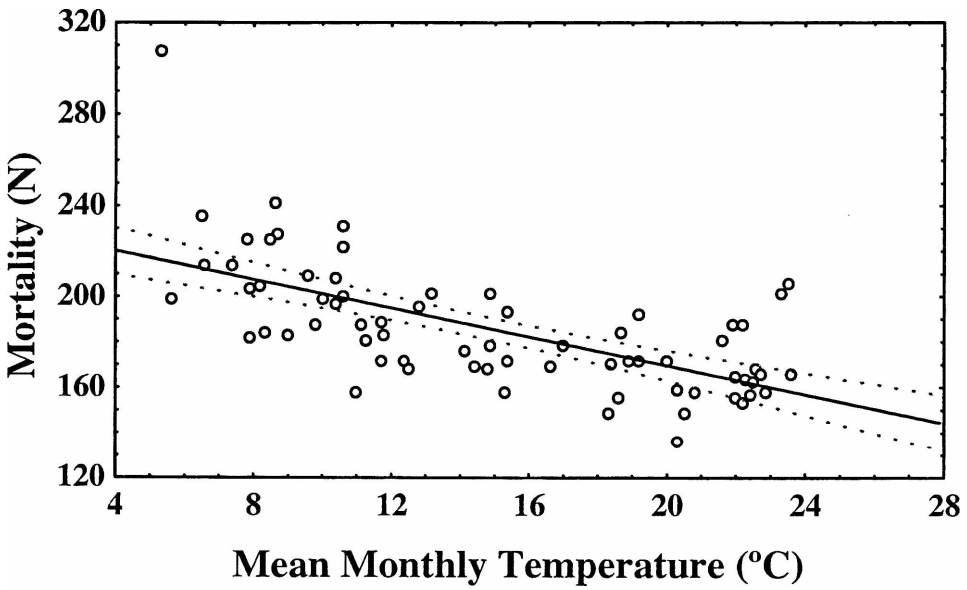

Figure 5. Regression line between mortality and mean monthly temperature

5. CONCLUSIONS

Bahía Blanca is a small city that had a fast development in the last decades, as new shopping, industries, etc. which created the need for the first background studies on the subject.

The analysis of the annual mortality rate in the city showed an average of 2231.8, that means that the city has a mean daily mortality of 6 persons. More than 50% of the mortality rate was not explained by the meteorological conditions, because they occur when the deviations in the mean temperatures are almost negligible (interval between -1 ıC and 1°C). However, we observed 13% of a mortality rate above normal when the mean temperatures are higher than the normal ones (interval between 3°C and 4°C). This may happen in any season or month of the year. Therefore, a decisive contribution of the weather conditions in mortality is found when a significant change in mean temperatures occurs in the city. A linear correlation equation between the two variables was found in the present study. This type of relationship is commonly found in the literature. Further studies taking into account other meteorological variables will be performed.

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References

Binkley, M.S., 1998. Human mortality as related to biometeorological factors. Reprints of the 11 Biometeorology and Aerobiology, American Meteorological Society, 374-377.

Bridger, C.A. and Helllfand, L.A., 1968. Mortality from Heat during July 1966 in Illinois. International Journal Biometeorology. 12, 51-70.

Capelli de Steffens A.; Píccolo, M.C; Varela, P. y Ferrera, I., 1985. El Clima Estival bahiense. Revista Universitaria de Geografía, Universidad Nacional del Sur, Bahía Blanca, Argentina, Vol. 1, N□1, 27-48.

Capelli de Steffens, Piccolo, M. C. y Campo de Ferreras, A. 1991. El confort estival de Bahía Blanca. Reprints CONGREMET VI, "La Meteorología en la actividad productiva en la Argentina", Centro Argentino de Meteorólogos, Buenos Aires, 117 - 118.

Capelli de Steffens A.; Campo de Ferreras, A. 1994. La transición climática en el sudoeste bonaerense. SIGEO 5. Dpto. de Geografía. Universidad Nacional del Sur, Bahía Blnaca, Argentina, pp.76

Capelli de Steffens, A., Piccolo, M.C. and Campo de Ferreras, A.M., 1995. Possible meteorological effects on mortality in Bahía Blanca, Argentina. *Annals Workshop Climatology and Air Pollution, International Association of Geography*, Universidad Nacional de Cuyo, Mendoza, 8-19.

Capelli de Steffens, A., Piccolo, M.C. y Campo de Ferreras, A.M., Bové, G., 1997. Aspectos bioclimáticos de la población en Bahía Blanca. Patrón de comportamiento estival. Actas de las *Primeras Jornadas Nacionales de Geografía Física*, Universidad Nacional del Sur, 189-194.

Capelli de Steffens, A.; Piccolo, M.C. y Campo de Ferreras, A., 1997. The influence of cold waves on mortality in Bahía Blanca. *ACTAS 19a Reunión Científica de Geofísica y Geodesia*, Universidad Nacional de San Juan, Argentina, 20-24.

Frost, D.B., Kaviani, M and Forest, C.M.1998. Temperature and heart attack in canadian cities. !3th Conf. On Biometeorology & Aerobiology, American Meteorological Society, 329-332.

International Statistical Classification of Diseases and related Health Problems, 1992. 10th Revision OMS, Ginebra, pp 1175.

Keatinge, W.R., 1986. Seasonal mortality among elderly people with unrestricted home heating. Br. Med. J., 293, 732-733.

Keatinge, W.R., Coleshaw, S.R.K., and Holmes, J., 1989. Changes in seasonal mortalities with improvement in home heating in England and Wales from 1964 to 1984. Int. J. Biometeorol. 33, 71-76.

Kunst, A.E., Looman C.W.N. and Mackenbach, J.P., 1991. Determinants of within-year fluctuations in mortality. Tijdschr Sociale Gezondheidsz 69, 123-131.

Landsberg, H.E., 1981. The urban climate. Academic press, N.Y., pp 274.

Lerchl, A, 1998. Changes in the seasonality of mortality in German from 1946 to 1995: the role of temperature. Int. J. Biometeorol, 42, 84-88.

Mackenbach, J.P., Kunst, A.E. and Looman C.W.N., 1992. Seasonal variation in mortality in The Netherlands. J. of Epidem. & Comm. Health 46, 261-265.

Píccolo, M.C. y Capelli de Steffens A.1985. Clima urbano bahiense: una experiencia de verano. Contribuciones científicas. XLII Semana de Geografía. Sociedad Argentina de Estudios Geográficos, Argentina, Tomo II, 382-396.

Piccolo, M. C. y Capelli de Steffens, A., 1987. Isla de calor invernal en Bahía Blanca. *Anales II Congreso Interamericano de Meteorologica* V CONGREMET (Argentina), Centro Argentino de , 14.1, 1-5.

Piccolo, M. C.; Perillo, G. M. E.; Ramon, C. G. and DiDio, V., 1988. Asthmatic outbreaks and meteorological parameters in Bahía Blanca, Argentina. Annals of Allergy 60, 107-110

Píccolo, M.C.; Capelli de Steffens, Alicia; Campo de Ferreras, Alicia, 1989. Variación espacial del viento en el área de Bahía Blanca, Revista Geofísica. (IPGH, México), 31, 205-220.

Piccolo, M. C.; Capelli de Steffens, A. y Campo de Ferreras, A., 1994. Efecto del viento en complejos edilicios bahienses. *Revista Geofísica*, N 41, IPGH, México, 5-19.

Roenneberg, T and Aschoff, J., 1990. Annual rhythm of human reproduction. I. Biology, sociology or both? J. Biol. Rhythms, 5, 195-216.

Tan G., 1991. Weather-related human mortality in Shanghai and Guangzhou, China. Tenth Conference on Biometeorology and Aerobiologgy. AMS, 15-17.

Tanaka, M and Tokudome S, 1991. Accidental hypothermia and death from cold in urban areas. Int. J. Biometeorol, 34, 242-246.

Truppi, L. E., 1983. A mortality standard for heat wave and cold wave episodes. Sixth Conference of Biometeorology and Aerobiology, AMS, 1-5.

Yao, C, Slattery, M.L., Jacobs, D.R., Folsom, A.R. and Nelson, E.T., 1991. Anthropometric predictors of coronary heart disease and total mortality: Findings from the US Railroad study. Am. J. of Epidemiology, 134, 11, 1278-1289.