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THE INFLUENCE OF BIOCLIMATIC FACTORS TO THE HOSPITALIZATIONS FOR CHILDHOOD ASTHMA IN ATHENS (1978-2000)

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EXTENDED ABSTRACT

The linkage among bioclimatic parameters such as discomfort index (a function of air temperature and relative humidity) and cooling power (a function of air temperature and wind speed) with the monthly number of asthma admissions (AA) in the Children's hospitals of Attica basin, during the period 1978-2000, was investigated. For this purpose, the monthly values of the aforementioned bioclimatic parameters were calculated using the meteorological data (air temperature, relative humidity and wind speed) recorded at the station of the National Observatory of Athens as well as the monthly number of hospitalizations for childhood asthma in "Agia Sophia", "P & A Kyriakou" and Penteli Children's hospitals. Children were classified into two age groups: 0-4 and 5-14 years.

The relationship among the monthly number of AA with the bioclimatic parameters was examined using the application of Pearson Chi Square Test and Generalized Linear Models (GLM) with Poisson distribution. The analysis of the results showed a statistically significant relationship ($p<0.001$) among the investigated parameters, especially as far as the children 0-4 years old concern. More specifically, a negative correlation was found between the discomfort index and AA, and a positive one between cooling power and AA. Interpreting the findings according to the GLM, a 10-unit increase in the discomfort index is associated with a 38% decrease in the likelihood of having an AA, while a 10-unit increase in the cooling power links to 78% increase in the probability of having an asthma hospitalization.

Concerning the 5-14 year old children's group there was not any significant relationship between the discomfort index and AA while a significant linkage between cooling power and AA was detected, but of lower order than the younger age group.

Key words: Childhood asthma, bioclimatic factors, GLM, Athens

1. INTRODUCTION

The association of asthma morbidity with weather conditions has been pointed out even at the 5th century BC by Hippocrates [1], while it is not clear enough to what extent more specific bioclimatic parameters are implicated in triggering asthma exacerbation. There is evidence that changes in temperature; barometric pressure and relative humidity have some influence on the worsening of asthmatic symptoms [2, 3, 4, 5, 6]. In Korea, relative humidity was found to be contributed as a more important factor than temperature to exercise induced bronchospasm in patients with perennial asthma [7].

A pronounced seasonal variation has already been reported for AA among children in Athens, rising during the cold damp period in the 0-4 year age group, but peaking around May in the 5-14 year age group [8]. An increasing rate of AA among children was also detected in a recent study in the metropolitan area of Athens, Greece, during the first sixteen years of the period between 1978 and 2000 and the more or less stabilization during the last few years. The mean annual increase in admission rate was 12.2% for 1978-87, 4.7% for 1988-93 and 0.6% for 1994-00 [9].

The objective of this study was therefore, to investigate if there is any association of specific bioclimatic parameters with the seasonal variation and time trend of asthma admissions among children in Athens during the period from 1978 to 2000.

2. DATA AND ANALYSIS

The medical data were obtained from the hospital registries of the three main Children's Hospitals of Athens for the 1978-00 period, covering approximately 78-80% of the paediatric beds of metropolitan area of Athens. All children admitted with the diagnosis of "asthma", "asthmatic bronchitis" or "wheezy bronchitis", aged 0-14 years, living in the above-mentioned region were included. They were classified into two age groups: 0-4 and 5-14 years. The monthly values of the bioclimatic parameters were calculated using the meteorological data (air temperature, relative humidity and wind speed) recorded at the station of the National Observatory of Athens for the aforementioned period.

Monthly AA rates, after adjusting for paediatric beds that are not accounted for (approximately 20-22% of total number), were expressed per 10^5 populations aged the same as the studied groups. The estimation of the population for each year of the study period was based upon the 1981 and 1991 national census. The whole studied period was split up into three shorter ones: 1978-87, 1988-93 and 1994-00, according to the findings of the previous study [9].

Concerning the bioclimatic indexes used in the analysis, Thom's discomfort index [10] is given by the formulae of Giles et al. [11]:

$$\mathbf{THI = T_a - 0.55(1 - 0.01\,RH)(T_a - 14.5)}$$

where T_a is the monthly value of the mean air temperature (°C), RH is the corresponding monthly value of the relative humidity (%).
The cooling power (CP) is given by the empirical formulae of Cena, Gregorczuck, Wojcik [12]:

$$CP = (0.412 + 0.087\, v)(36.5 - T_a)$$

where v is the monthly mean wind speed (m/sec) and T_a is the monthly mean air temperature (^oC).

Regarding the population of the greater Athens area, there is no discomfort when THI<21^0C, less than 50% of the total population feels discomfort when $21^0C \le THI < 24^0C$, more than 50% of the total population feels discomfort when $24^0C \le THI < 27^0C$, most of the population suffers from discomfort when $27^0C \le THI < 29^0C$, while the discomfort is very strong and dangerous when $29^0C \le THI < 32^0C$. In the last case, a prescribe state of medical emergency must be taken. The cooling power has been related to sensation scale, which can be classified as follows:

Cooling power (mcal cm^{-2} sec^{-1})	Sensation
≤ 5	Hot
$5 < CP \le 10$	Pleasant or mild
$10 < CP \le 15$	Cool
$15 < CP \le 22$	Cold
$22 < CP \le 30$	Very cold
> 30	Extreme cold

The relationship between AA and the aforementioned bioclimatic parameters was calculated by the application of: a) Pearson χ^2 test, the most widely used method of independence control of groups in lines and columns in a table of frequencies b*)* Generalized Linear Models (GLM) with Poisson distribution.

In the first step of the detailed statistical analysis, the values of each bioclimatic parameter and AA, were grouped in five quintiles, so that the first quintile contain the lowest 20% and the fifth quintile the highest 20% of the values. In the process, the number of months for the quintiles of AA was calculated for each quintile of the bioclimatic parameters and then a contingency table was constructed for every bioclimatic parameter. Tables 1 and 2 present the contingency tables for the discomfort index and the cooling power. The Pearson χ^2 test was applied in each one of the two contingency tables, checking the null hypothesis that the quintiles of each bioclimatic parameter are not related (hence they are independent) to the quintiles of AA. The use of contingency tables instead of Pearson correlation considered more accurate, because the medical data present large divergence from a Gaussian (regular) distribution.

In the second step of the performed analysis, the statistical importance of the correlation between the frequency of AA and the bioclimatic parameters was examined by the application of GLM with Poisson distribution described by McGullagh and Nelder [13]. In the models fitting procedure we used as dependent variable the monthly number of AA in the Children's hospitals of Attica basin, while as independent covariates the aforementioned bioclimatic parameters. Models' goodness-of-fit was evaluated through the deviance residuals [13].

3. RESULTS and DISCUSSION

Figure 1 depicts the annual variation of the mean monthly number with AA and the bioclimatic parameters for the period 1978-2000. The annual march of THI values is in opposite phase to the hospitalizations for childhood asthma (0-4 years old). During summer months, the presence of minimum AA corresponds with maximum of THI. The interpretation of this phenomenon is that in summer months, the air temperature reaches its maximum and additionally the vapor pressure, which follows an opposite variation to the relative humidity, also reaches its maximum because of the maximum evaportraspiration. These environmental conditions minimize AA. Concerning the mean monthly CP values, there is a consequence with the corresponding AA values. High air temperature and low wind speed during summer days create a stable environment where the already water vapors do not disperse and these conditions seem to be beneficial for asthmatic children.

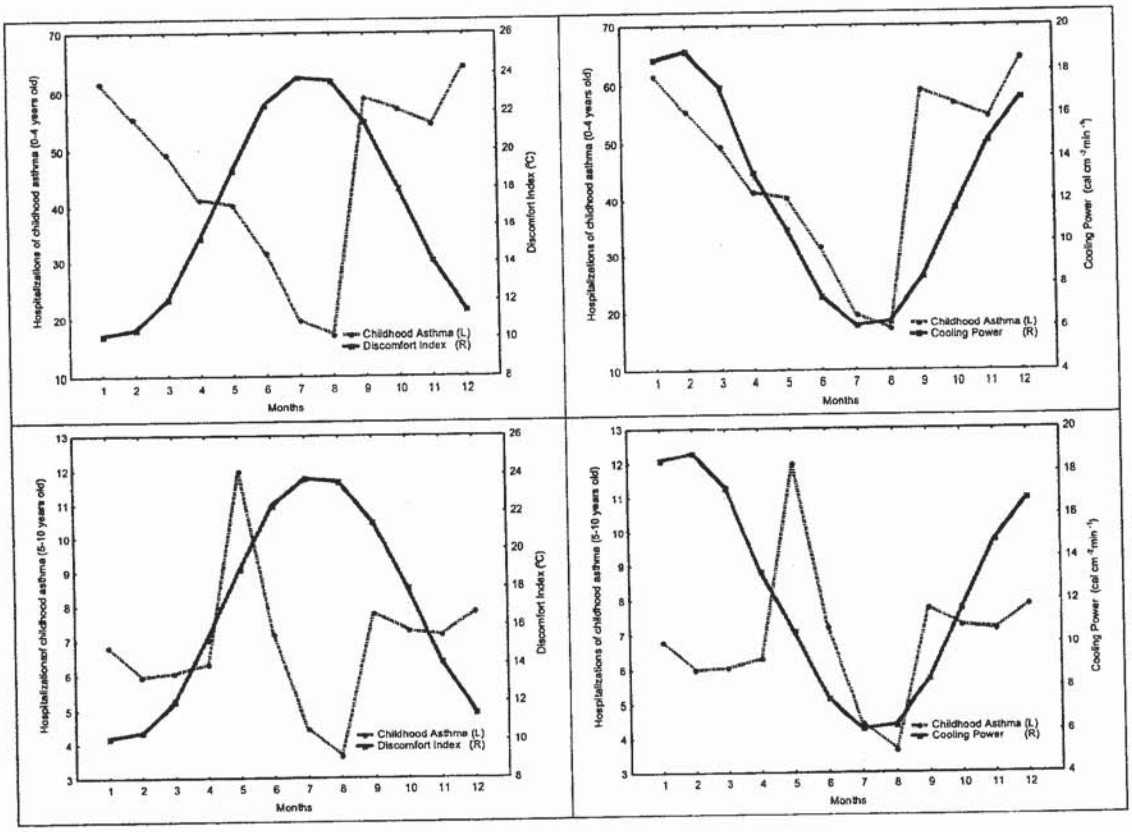

Figure 1: The annual variation of the mean monthly number of AA and the bioclimatic parameters for the period 1978-2000.

Concerning the childhood asthma for 5-14 year age group, two maxima appear (the main one occurs in May and the secondary one in September) while the minimum happens in August and this is in agreement with Priftis et al. findings [8].

In the process, we applied Pearson Chi Square Test on the constructed contingency tables for the quintiles of AA for every quintile of the aforementioned bioclimatic parameters. It is crystal clear from Table 1, that the first quintile of AA ($AA \leq 22.6$) is related to the last quintile of THI ($THI > 22.5$), and this is statistically significant ($p=0.05$), approved by the application of Pearson χ^2 test. On the contrary, Table 2 shows that the first quintile of AA ($AA \leq 22.6$) is related to the first quintile of CP (CP≤11.4), and this is statistically significant (p=0.05), as well.

Table 1: Number of months for the quintiles of monthly number of AA for each quintile of the discomfort index (THI).

Quintiles of THI (°C)	Quintiles of AA (0-4 year old)				
	AA≤22.6	**22.6<AA≤36.7**	**36.7<AA≤52.8**	**52.8<AA≤69.5**	**AA>69.5**
1 THI≤11.4	2	8	12	17	17
2 11.4<THI≤14.4	6	10	10	17	12
3 14.4<THI≤18.9	10	8	14	11	12
4 18.9<THI≤22.5	7	12	14	8	14
5 THI>22.5	30	17	6	2	0

Pearson Chi Square: 83.114, Degrees of Freedom: 16

Table 2: Number of months for the quintiles of monthly number of AA for each quintile of the cooling power (CP).

Quintiles of CP (cal cm^{-2} min^{-1})	Quintiles of AS (0-4 years old)				
	AA≤22.6	**22.6<AA≤36.7**	**36.7<AA≤52.8**	**52.8<AA≤69.5**	**AA>69.5**
1 CP≤11.4	32	18	6	2	1
2 11.4<CP≤14.4	9	14	15	5	11
3 14.4<CP≤18.9	9	10	14	12	9
4 18.9<CP≤22.5	3	10	8	20	14
5 CP>22.5	2	3	13	16	20

Pearson Chi Square: 105.202, Degrees of Freedom: 16

The application of Pearson χ^2 test both to the clinical and bioclimatic data reveals the qualitative relationship between them. The quantitative relationship is examined by the application of GLM with Poisson distribution in the data, performed quite satisfactory in previous studies [14, 15]. The results extracted by this analysis are tabulated in Table 3. For the first age group (0-4 year old), a statistically significant negative correlation was found between THI and AA (β=-0.05, p<0.001). The interpretation of the result is that, a 10-unit increase in the discomfort index raise by 38% the probability of having AA. For CP, a statistically significant positive correlation was found with hospital admissions (β=-0.06, p<0.001). A 10-unit increase in the cooling power yields a 78% increase in the likelihood of having AA. An increase in CP values means the sensation of the environment is getting colder because of low air temperature and high wind speed, especially during the cold period of the year.

Table 3: Results of the application of Generalised Linear Models (GLM) with Poisson distribution, (dependent variable the monthly number of AA, while independent covariates the aforementioned bioclimatic parameters).

		β-coefficient ± S.E.	p
Asthma admissions	**THI (°C)**	-0.0481 ± 0.0018	0.000000
(0-4 year old)	**CP(cal cm^{-2} min^{-1})**	0.0578 ± 0.0018	0.000000
Asthma admissions	**THI (°C)**	-0.0067 ± 0.0045	0.136687
(5-10 year old)	**CP(cal cm^{-2} min^{-1})**	0.0167 ± 0.0047	0.000362

For the second age group (5-10 year old), a statistically significant positive correlation was found between CP and AA (β=-0.02, $p<0.001$). A 10-unit increase in the cooling power is associated with an 18% increase in the probability of having AA. The low percentage extracted it is possible to be connected with the peak of AA in May (see Figure 1).

4. CONCLUSIONS

The bioclimatic conditions, as they are represented by the discomfort index and the cooling power, seems to effect on the number of AA in the Children's hospital of Attica basin. It was found that, for the first age group (0-4 year old), the values of the discomfort index within the fifth quintile (THI>22.5) are associated with the first quintile of the number of AA (AA≤22.6). Furthermore it was found that, a 10-unit increase in the discomfort index raise by 38% the probability of having an AA. A statistically significant positive correlation between the cooling power and AA was established. More specifically the values within the first quintile of CP (CP≤11.4) are related to the first quintile of the number of AA (AA≤22.6). A 10-unit increase in the cooling power yields a 78% increase in the likelihood of having an AA. For the second age group (5-10 year old), a statistically significant positive correlation was found between CP and AA, but of low order in comparison to the first age group.

The findings of the analysis make clear that the combined influence of meteorological parameters, such as air temperature, relative humidity and wind speed, on the children's AA is well established and the pronounced indexes could be predictors of the worsening of children's health, concerning asthma exacerbations.

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