Hrvatski meteorološki časopis, 29, pp. 1–10, 1994.

UDK: 551.506
Originalni znanstveni rad

WEATHER CONDITIONS AND THE SINO-BRONCHIAL SYNDROME IN CHILDREN IN ZAGREB

Vremenske prilike i sino-bronhalni sindrom kod djece u Zagrebu

NADA PLEŠKO
Državni hidrometeorološki zavod,
Grič 3, 41000 Zagreb, Hrvatska

MILICA KRSTIĆ-BURIĆ, MAJA MEDAR-LASIĆ, DURĐICA MILKOVIĆ, MAJA BAŠIĆ-GRBAC
Bolnica za tuberkulozu i plućne bolesti djece i omladine
Srebrnjak 100, 41000 Zagreb, Hrvatska

SANJA PLEŠKO
Dom zdravlja Trešnjevka
41000 Zagreb, Hrvatska

Primljeno 5. rujna 1994, u konačnom obliku 20. listopada 1994.

Abstract – This paper deals with the dependence of the chronic sino-bronchial syndrome and respiratory tract acute diseases in children and adults (age 0–19) living in Zagreb (a town with developed industry and heavy road traffic) on meteorological elements acting on man's thermal sensation. This study is based on the bioclimatic index i/H (air enthalpy and cooling power rate) and the relevant bioclimatic classification and on those meteorological elements that are included in the bioclimatic index calculation (air temperature, relative humidity, wind speed and barometric pressure). A correlation analysis method has been applied on both daily data and 3-, 5- and 7-day moving average values. All analyses have been done separately for the cold and warm part of the year. The results for the cold and warm parts of the year differ. Chronic patients react earlier to meteorological stress than acute ones. In the cold part of the year the warm periods are critical while in the warm part of the year the cold ones are critical. Along with the air temperature relative humidity is also significant. For acute patients periods with high relative humidity are particularly unfavourable, both in the cold and warm periods of the year, if they last at least three days. SO_2 and smoke concentration in the studied period (1988–90) was within the allowed limits and their correlation with sino-bronchial diseases, chronic or acute, was not significant.

Key word index: sino-bronchial syndrome in children, chronic, acute, weather conditions, thermal comfort, meteorological elements, concentration of SO_2 and smoke, correlation analysis.

Sažetak - Ispitivana je ovisnost kroničnoga sino-bronhalnog sindroma i akutne bolesti respiratornoga trakta kod djece i omladine (dob 0-19 godina) u Zagrebu, gradu s dosta razvijenom industrijom i jakim prometom, o onim meteorološkim elementima koji djeluju na toplinski osjet čovjeka. Ispitivan je i utjecaj zagađenosti atmosfere sa sumpornim dioksidom i dimom, jer podacima o drugim polutantima nismo raspolagali. Baza su bili podaci o bolesnicima koji su bili primljeni na liječenje u Dječju bolnicu za plućne bolesti na Srebrnjaku 1988–90. Proučavanje je provedeno uz pomoć bioklimatskoga indeksa i/H (omjer entalpije i indeksa ohlađivanja) i pripadne bioklimatske klasifikacije, ali i uz pomoć onih pojedinačnih meteoroloških elemenata (temperature zraka, relativne vlage, brzine vjetra i tlaka zraka) na osnovi kojih se računa bioklimatski indeks. Metoda korelacione analize primijenjena je ne samo na dnevne podatke nego i na 3-, 5-, i 7-dnevne klizne srednje vrijednosti. Sve su analize provedene odvojeno za hladni i topli dio godine. Rezultati su različiti za hladni i topli dio godine. Kronični bolesnici reagiraju prije na meteorološke podražaje od akutnih. U hladnom dijelu godine opasnija su razdoblja topla vremena, a u toplom dijelu opasnija su hladna razdoblja. Signifikantnost je to veća što duže takva razdoblja traju. Uz temperaturu zraka važna je i visoka relativna vlaga. Za akutne bolesnike osobito su nepovoljna razdoblja s visokom relativnom vlagom zraka, i u hladnom i u toplom periodu godine, ako ona traju barem tri dana. U proučavanom periodu koncentracije SO_2 i dima bile su unutar dopuštenih granica i nije dobivena signifikantna korelacija sa sino-bronhalnom bolešću.

Ključne riječi: sino-bronhalni sindrom kod djece, kronični, akutni, vremenske prilike, toplinski osjet, meteorološki elementi, koncentracije SO_2 i dima, korelaciona analiza.

1. INTRODUCTION

Respiratory diseases are frequently related to weather and air pollution, not only as the patients' subjective feeling or their relatives' impressions, but also as the result of many scientific studies (Tromp, 1963, 1980; Kolbas, 1982; Milleron et al. 1988; Ayres, 1986; Katzschner, 1990; Islam, 1993).

In northern Europe and the USA, respiratory diseases are most frequent among various meteorotropic diseases, especially asthma and bronchitis, as affirmed by the well-known bio-meteorologist Tromp (1980). Bringing out the results of his study for Holland and presenting the results of many other investigators from various parts of the world, he carries out numerous highly significant correlations between the asthma and bronchitis incidence and various meteorological parameters (Tromp, 1963, 1980).

A highly significant correlation exists between the asthma incidence and atmospheric cooling, which is the result of the simultaneous effect of air temperature and wind speed. Not only atmospheric cooling but also significant raise in heat, especially in combination with high relative humidity, can cause strong asthmatic attacks. The increase in the number of asthmatic attacks is also correlated to atmospheric cold fronts going along with sudden changes of barometric pressure and air temperature, often accompanied by heavy precipitation and significant disturbance of the atmospheric electricity field (fluctuation of atmospheric electricity gradient potential between high positive and negative values), sudden changes in wind speed and direction, etc. (Tromp 1980).

Our preliminary study on weather and asthma attack correlation in children being cured on the island of Lošinj (Children's Hospital-Veli Lošinj on the Adriatic coast) indicated that unfavourable weather conditions were similar to those quoted by Tromp (Vukelić and Pleško, 1990).

Even a common cold, with its minimum in February and its maximum in the period from February to March (on the northern hemisphere), according to Tromp (1980) indicates an incidence increase in Holland and England along with a temperature decrease and humidity increase. Many respiratory diseases are, consequently, related to weather conditions.

The purpose of this study is to find if inflammatory processes of the upper and lower respiratory tract (sino-bronchial syndrome) in children and adolescents in Zagreb, seeking help in a hospital, can be connected with weather or air pollution, or both.

2. DATA

Three kinds of data were used for this study: medical, meteorological and chemical.

a) Medical data, prepared at the Children's Hospital – Srebrnjak, contain the daily number of patients with
- a chronical sino-bronchial syndrome and
- an acute disease of the upper and lower respiratory tracts

among children and adolescents aged 0–19, for the period 1988–90 in Zagreb.

b) Meteorological data were measured at the Meteorological-aerological Observatory Zagreb–Maksimir and put at our disposal by the Meteorological and Hydrological Service of Croatia (MHSC). We used:
- the mean daily values of
- air temperature
- relative humidity
- wind speed and
- barometric pressure

for the same period (1988-90).

c) Chemical data were also put at our disposal by MHSC, and contain the concentrations of:
- SO_2 and
- smoke

measured at the Meteorological Observatory Zagreb–Grič. It is not the best locality for an air pollution sample of the broad territory of the town where the observed children live. Chemical analysis methods are adequate for regions with low concentrations, and can not indicate higher concentrations of SO_2 and smoke. Unfortunately, the Institute for Medical Research and Work Medicine having a denser and more representative net of measuring stations in Zagreb was not allowed to supply data for research. We, therefore, had to use the chemical data measured at the Observatory Zagreb–Grič, keeping in mind that only the relative relation and trend of these data could be used to reach conclusions.

3. METHOD

All analyses have been performed separately for the cold (October – March) and warm (April – September) parts of the year, and for the whole year.

A correlation analysis, along with the basic statistical sample characteristics of chronic and acute patients, has been done for:
- the daily number of chronic and acute patients with the daily values of the mentioned meteorological elements and hereafter
- for the 3-, 5-, and 7-day moving averages of the number of chronic and acute patients and the simultaneous moving averages of meteorological elements because it is not known how fast a grown-up person or child reacts to stress from the atmosphere.

For the same moving periods (1-,3-.5- and 7-days)
- the bioclimatic index i/H (Pleško, 1976) was calculated and correlated to the simultaneous chronic and acute disease incidence.

This index takes into consideration the synthesized effect of air temperature, humidity and wind speed upon body cooling. It is combined from two well known indices: air enthalpy i (Böer, 1964) and cooling power H (Conrad and Pollak, 1950; Landsberg, 1972) and can be calculated from eq.:

$$i = 1004 \left(t_w + \frac{1555}{p} E_t\right)$$

where: i = air enthalpy (Jkg^{-1}); t_w = wet bulb temperature (°C); p = barometric pressure (hPa) at temperature t; E_t = saturated vapour pressure at temperature t; v = wind speed (ms^{-1}); H = cooling power ($kJm^{-2}s^{-1}$) and

$H=(0.20+0.40\,v^{0.5})\,(36.5-t)$ for $v < 1 ms^{-1}$

$H=(0.13+0.47\,v^{0.5})\,(36.5-t)$ for $v \geq 1 ms^{-1}$,

with the relative bioclimatic classification (Pleško, 1979, 1983; Novaković, 1983):

THERMAL SENSATION	*i/H*
EXTREMELY COLD	< 5
COLD	5 – 15
COOL	5 – 35
COMFORTABLE	35 – 85
WARM	85 – 155
UNPLEASANTLY WARM	155 – 205
SULTRY	205 – 310
DANGEROUSLY WARM	> 310

4. RESULTS AND DISCUSSION

The study included only children permanently living in Zagreb (excluding the outskirts). On this territory there are some factories (Pliva, Frank, Kraš etc). At the same time, the town core has relatively narrow streets with heavy traffic and therefore a lot of exhaust gases polluting the town environment adding to factory pollution.

The study is based on 207 patients with a diagnosis of sino-bronchial syndrome, i.e. chronic sinusitis and simultaneous bronchitis. We did not distinguish the etiology of the sino-bronchial syndrome in our sample.

A group of 100 patients with an acute disease of the upper and lower respiratory tracts cured in hospital during the same period was included in the study as well.

The hospital admission date was the basis for studying the correlation between the disease frequency and the weather. All patients were radiologically treated and all have undergone routine haematological, bacteriological and alergological treatments; and the epiometric test of patients being ready for collaboration.

4.1. THE CHARACTERISTICS OF THE MEDICAL SAMPLE

The distribution of 207 chronic patients according to age and sex (Figure1) indicates that there were more boys (134) than girls (73). The most frequent group (107) were patients aged 5–9 and among them boys prevailed again (68 boys to 39 girls).

In the group of 100 acute patients the distribution was similar; the majority was made up by boys (61) and the most numerous was again the group aged 5–9 (32 boys and 20 girls).

The results of the lung function test on 200 patients able to collaborate (Table 1) revealed that lung venti-

Table 1. Lung function test on patients able to collaborate

Tablica 1. Test plućne funkcije kod bolesnika sposobnih za suradnju

Test	Chronic	Acute
Normal	68	90
Obstruction	42	0
Total	110	90

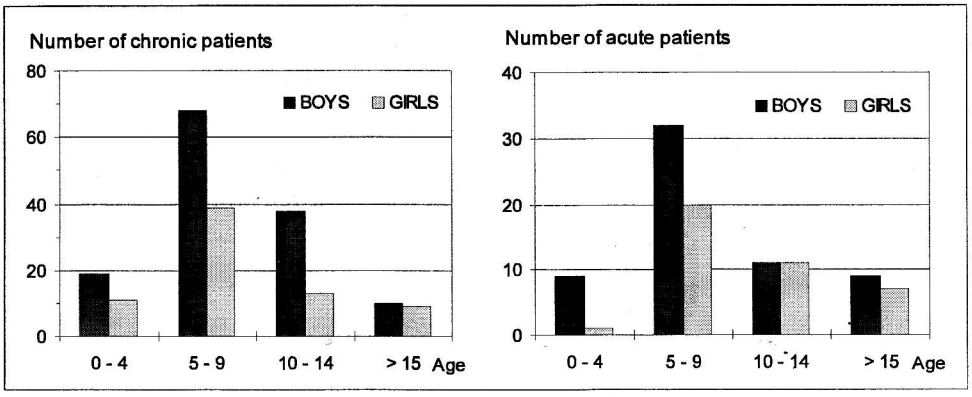

Figure 1. Distribution of chronic and acute patients according to age and sex

Slika 1. Razdioba kroničnih i akutnih bolesnika prema dobi i spolu

Table 2. Sample of chronic sino-bronchial syndrome

Tablica 2. Uzorak kroničnog sino-bronhalnoga sindroma

	Year	Cold part	Warm part
Number of days	1095	546	549
Total number of patients	207	109	98
Daily mean number of patients	0.19	0.20	0.18
St.deviation	0.45	0.48	0.42
Min.number per day	0	0	0
Max.number per day	3	3	2

Table 3. Sample of acute respiratory disease

Tablica 3. Uzorak akutne respiratorne bolesti

	Year	Cold part	Warm part
Number of days	1095	546	549
Total number of patients	100	61	39
Daily mean number of patients	0.09	0.11	0.07
St.deviation	0.30	0.33	0.26
Min.number per day	0	0	0
Max.number per day	2	2	2

lation was normal with all 90 patients suffering from acute sinusitis and bronchitis. Of the patients suffering from a chronic sino-bronchial syndrome 61% had normal ventilation and 39% suffered from obstructive ventilation interruptions.

Only a slightly greater mean number of chronic patients (Table 2) were admitted to hospital in the cold part (X – III) of the year than in the warm (IV – IX) part. On some days no cases were registered, while the greatest daily number was three cases in the cold part of the year.

The mean number of acute patients admitted to hospital per day was a half of the number of chronic patients (Table 3). Acute patients were also more frequent in the cold part of the year than in the warm part. In both parts of the year the registered maxima were only two acute cases per day but there were many days without any registered case.

4.2. A CORRELATION ANALYSIS OF THE SINO–BRONCHIAL SYNDROME AND THE BIOMETEOROLOGICAL INDEX *I/H*

The joint, simultaneous, effect of air temperature, relative humidity and wind speed on disease occurrence has been studied by using the biometeorological index i/H (Tables 4–7).

It is easily visible that even one cool day (on an average) in the warm part of the year (Table 4, column *i/H*) significantly increases the incidence of the chronic sino-bronchial syndrome ($P < 0.01$). This correlation is reflected also on the year as a whole (although with a smaller significance); taking into account that the unfavourable meteorolological conditions in the cold and warm parts of the year are opposite.

According to the correlation analysis acute diseases of the upper and lower respiratory tracts are not connected with a thermal sensation lasting only one day.

Chronic patient sensibility to thermal sensation for the whole year is clearly visible in the 3-day moving average series (Table 5), indicating that in the warm part of the year 3-day cold periods are significant ($P < 0.0001$), while in the cold part warm periods are significant ($P < 0.001$). A more significant relationship of the same characteristics between weather and the chronic sino-bronchial syndrome is obtained for 5-day (Table 6) and 7-day (Table 7) moving periods.

According to thermal sensation, a significant increase in acute diseases follows only a seven-day warming in the cold part of the year ($P < 0.05$). Shorter warming periods in the cold part of the year, apparently, do not bring an acute disease manifestation in predisposed children or, possibly, they do not seek immediate help in hospital. In the warm part of the year the thermal sensation in acute patients is not significant before 7-day moving periods, although significant correlations were acquired for single meteorological elements (low air temperature and high relative humidity).

An analysis of the thermal sensation type and the frequency of chronic and acute diseases was carried out for every day data for the cold and warm parts of the year (Figure 2).

First, every day was bioclimaticaly classified and the probability of such day coming in the cold and warm periods was defined on the basis of data for the period 1988–90.

Table 4. Coefficients of the linear correlation between the daily frequency of the chronic sino-bronchial syndrome and acute disease of the upper and lower respiratory tracts and the meteorological elements for a day; Zagreb 1988–90.

Tablica 4. Koeficijenti linearne korelacije između dnevne učestalosti kroničnog sino-bronhalnoga sindroma kao i akutne bolesti gornjega i donjega dišnoga trakta i meteoroloških elemenata za dan; Zagreb, 1988–90.

		COLD PART OF THE YEAR					WARM PART OF THE YEAR				
		t	*h*	*w*	*p*	*i/H*	*t*	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	–0.0226	0.0079	0.0200	–0.242	–0.0643	–0.1268	0.0184	0.0451	0.0516	–0.1163
	n	(1095)	(1095)	(1095)	(1095)	(1095)	(549)	(549)	(549)	(549)	(549)
	P	0.4541	0.7949	0.5094	0.4238	0.0333	0.0029	0.6677	0.2918	0.2276	0.0064
ACUTE	*r*	–0.0513	0.0796	–0.0508	0.0385	–0.0183	–0.0187	0.0378	–0.0652	–0.0421	0.0153
	n	(1095)	(1095)	(1095)	(1095)	(1095)	(549)	(549)	(549)	(549)	(549)
	P	0.0897	0.0084	0.0927	0.2031	0.5442	0.6627	0.3770	0.1217	0.3253	0.7210

		YEAR				
		t	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	–0.0226	0.0079	0.0200	–0.242	–0.0643
	n	(1095)	(1095)	(1095)	(1095)	(1095)
	P	0.4541	0.7949	0.5094	0.4238	0.0333
ACUTE	*r*	–0.0513	0.0796	–0.0508	0.0385	–0.0183
	n	(1095)	(1095)	(1095)	(1095)	(1095)
	P	0.0897	0.0084	0.0927	0.2031	0.5442

r – correlation coefficient
n – number of cases
P – significance level
t – temperature
h – relative humidity
w – wind speed
p – barometric pressure
i/H – bioclimatic index

Table 5. Coefficients of the linear correlation between the 3-day moving average frequency of the chronic sino-bronchial syndrome and acute disease of the upper and lower respiratory tracts and the 3-day moving averages of meteorological elements; Zagreb 1988–90.

Tablica 5. Koeficijenti linearne korelacije izmedu 3-dnevnih kliznih srednjih učestalosti kroničnog sino-bronhalnoga sindroma te akutne bolesti gornjega i donjega dišnog trakta i 3-dnevnih kliznih srednjaka meteoroloških elemenata; Zagreb, 1988–90.

		COLD PART OF THE YEAR					WARM PART OF THE YEAR				
		t	*h*	*w*	*p*	*i/H*	*t*	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	0.1370	–0.0294	–0.0140	–0.1049	0.1410	–0.2303	0.1014	0.0234	0.0684	–0.2226
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.0013	0.4928	0.7436	0.0140	0.0009	0.0000	0.0175	0.5835	0.1092	0.0000
ACUTE	*r*	0.0315	0.1465	–0.0470	0.0647	0.0688	–0.0622	0.0880	–0.0728	–0.0469	0.0364
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.4623	0.0006	0.2716	0.1301	0.1074	0.1454	0.0394	0.0885	0.2729	0.3947

		YEAR				
		t	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	–0.0362	0.0405	–0.0030	–0.0433	–0.1121
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.2304	0.1797	0.9199	0.1517	0.0002
ACUTE	*r*	–0.0930	0.1606	–0.0691	0.0659	–0.0350
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.0020	0.0000	0.0220	0.0292	0.2472

r – correlation coefficient
n – number of cases
P – significance level
t – temperature
h – relative humidity
w – wind speed
p – barometric pressure
i/H – bioclimatic index

Table 6. Coefficients of the linear correlation between the 5-day moving average frequency of the chronic sino-bronchial syndrome and acute disease of the upper and lower respiratory tracts and the 5-day moving averages of meteorological elements; Zagreb 1988–90.

Tablica 6. Koeficijenti linearne korelacije izmedu 5-dnevnih kliznih srednjih učestalosti kroničnog sino-bronhalnoga sindroma te akutne bolesti gornjega i donjega dišnog trakta i 5-dnevnih kliznih srednjaka meteoroloških elemenata; Zagreb, 1988–90.

		COLD PART OF THE YEAR					WARM PART OF THE YEAR				
		t	*h*	*w*	*p*	*i/H*	*t*	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	0.1759	–0.0080	–0.0461	–0.1268	0.1804	–0.2728	0.1707	–0.0034	0.0524	–0.2897
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.0000	0.8515	0.2810	0.0029	0.0000	0.0000	0.0001	0.9357	0.2203	0.0000
ACUTE	*r*	0.0371	0.1820	–0.0846	0.0844	0.0812	–0.0743	0.0948	–0.0350	–0.0704	0.0575
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.3857	0.0000	0.0478	0.0484	0.0576	0.0818	0.0264	0.4128	0.0993	0.1782

		YEAR				
		t	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	–0.0380	0.0857	–0.0423	–0.0574	–0.1397
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.2083	0.0045	0.1614	0.0571	0.0000
ACUTE	*r*	–0.1195	0.1975	–0.0803	0.0860	–0.0441
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.0001	0.0000	0.0078	0.0044	0.1443

r – correlation coefficient
n – number of cases
P – significance level
t – temperature
h – relative humidity
w – wind speed
p – barometric pressure
i/H – bioclimatic index

Table 7. Coefficients of the linear correlation between the 7-day moving average frequency of the chronic sino-bronchial syndrome and acute disease of the upper and lower respiratory tracts and the 7-day moving averages of meteorological elements; Zagreb 1988–90.

Tablica 7. Koeficijenti linearne korelacije izmedu 7-dnevnih kliznih srednjih učestalosti kroničnog sino-bronhalnoga sindroma te akutne bolesti gornjega i donjega dišnog trakta i 7-dnevnih kliznih srednjaka meteoroloških elemenata; Zagreb, 1988–90.

		COLD PART OF THE YEAR					WARM PART OF THE YEAR				
		t	*h*	*w*	*p*	*i/H*	*t*	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	0.2067	0.0241	–0.0948	–0.1545	0.2174	–0.3047	0.2221	–0.0173	0.0313	–0.3382
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.0000	0.5740	0.0264	0.0003	0.0000	0.0000	0.0000	0.6861	0.4636	0.0000
ACUTE	*r*	0.0409	0.1907	–0.1090	0.0928	0.0863	–0.0899	0.0943	0.0118	–0.0823	0.0596
	n	(548)	(548)	(548)	(548)	(548)	(549)	(549)	(549)	(549)	(549)
	P	0.3393	0.0000	0.0107	0.0298	0.0435	0.0352	0.0271	0.7819	0.0540	0.1629

		YEAR				
		t	*h*	*w*	*p*	*i/H*
CHRONIC	*r*	–0.0373	0.1268	–0.0829	–0.0764	0.1551
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.2175	0.0000	0.0060	0.0113	0.0000
ACUTE	*r*	–0.1436	0.2154	–0.0816	0.1025	–0.0615
	n	(1097)	(1097)	(1097)	(1097)	(1097)
	P	0.0000	0.0000	0.0069	0.0007	0.0418

r – correlation coefficient
n – number of cases
P – significance level
t – temperature
h – relative humidity
w – wind speed
p – barometric pressure
i/H – bioclimatic index

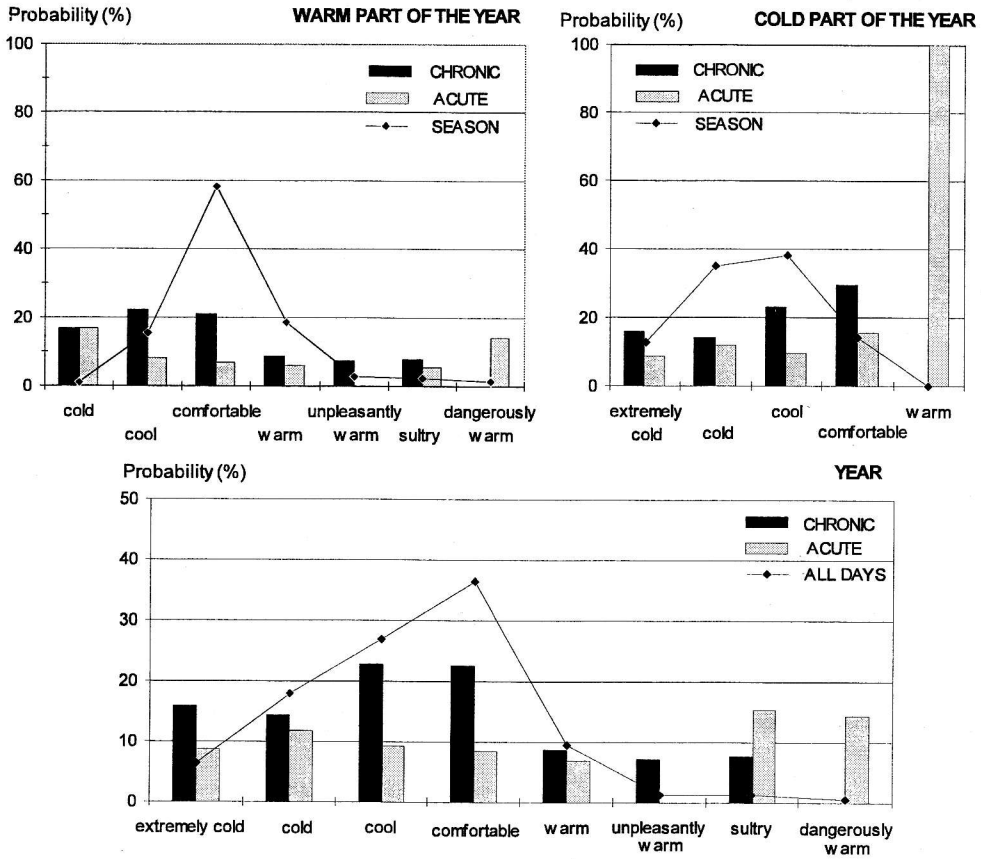

Figure 2. Thermal sensation in the cold and warm parts of the year, and the whole year, for days with chronic and acute disease occurence, Zagreb, 1988–90.

Slika 2. Toplinski osjet u hladnom i toplom dijelu godine, kao i u cijeloj godini, u danima pojave kronične i akutne bolesti, Zagreb, 1988–90.

The line indicating the probability of thermal sensation in the cold and warm parts of the year is designated as "season" and the one relating to the whole year as "all days". A conditional probability (%) of the incidence of chronic or acute diseases is conditioned by a specific thermal sensation and the figures are marked "chronic" or "acute". The correlation coefficients provide only a qualitative representation of the correlation between the biometeorological index (thermal sensation) and the disease frequency while we would like to discuss true thermal sensation recognized by everybody.

In the cold part of the year the most frequent feelings in Zagreb were commonly "cool" and then "cold", but the highest conditional probability for the chronic sino-bronchial syndrome was found in "comfortable" and "cool" days.

The chronic sino-bronchial syndrome in the warm part of the year, when days are commonly "comfortable", has the highest conditional probability during "cool", "comfortable" and "cold" days. Obviously, colder thermal sensations are prevailing in the warm part of the year when the chronic sino-bronchial syndrome is the most frequent, which is in good agreement with the correlation analysis results.

According to the correlation analysis, acute respiratory diseases are not significantly correlated to a thermal sensation lasting one day. A high conditional probability of acute diseases (100%) along with a "warm" sensation in the cold part of the year is unreliable because of only one "warm" day and one acute patient. In the warm part of the year, acute respiratory diseases are also frequent when the thermal sensation is "cold", but relationships were insignificant as indicated by the correlation coefficients. The study of thermal sensations reveals that the cause of their insignificancy is the high conditional probability of acute diseases in "sultry" and "dangerously warm" days, when relative humidity is high and very harmful for the respiratory tract. These opposite thermal sensations reduce the significance of the correlation coefficient.

4.3. A CORRELATION ANALYSIS OF DISEASE FREQUENCY AND SINGLE METEOROLOGICAL ELEMENT

This analysis comprises the meteorological elements important for body cooling and the resulting thermal sensation, calculated by means of the bioclimatic index *i/H*.

The correlation analysis carried out shows interesting results, especially when the cold and warm parts of the year are compared. The correlations are the more significant the longer the moving periods are.

The data for a day (Table 4) indicate a significant relationship only between the chronic sino-bronchial syndrome and air temperature in the warm part of the year ($P < 0.01$). As the air temperature was lower the number of chronic patients seeking help at the hospital was higher. For the cold part of the year no significant correlations with the weather were noticed, neither in chronic nor acute patients.

In the average for the whole year, the number of acute patients increased significantly ($P < 0.01$) in days with a high relative humidity, but this significance disappears if the cold and warm parts of the year are analysed separately.

There is a more important correlation between weather and disease frequency if we consider the weather characteristics not only for a day but through more days. The correlation analysis has thus been repeated for 3-, 5-, and 7- day moving averages (Table 5 – Table 7).

In the 3-day moving averages (Table 5) a significant dependence of chronic patients on air temperature is already evident both in the warm ($P < 0.0001$) and cold ($P < 0.01$) parts of the year. As the temperature grew higher in the cold part, or lower in the warm part of the year, more patients were seeking help in hospital. Another element significant for chronic patients can be noticed in Table 5; it is air pressure. As in the cold part of the year the 3-day periods show lower barometric pressure ($P < 0.05$) and higher temperature ($P < 0.01$) there is a more worsening in chronic patients.

Low temperatures ($P < 0.0001$) in the warm part of the year along with high relative humidity ($P < 0.05$) are significant for chronic patients.

Acute patients (Table 5) seem to be more responsive to high humidity. We have significant positive correlations for both the cold ($P < 0.001$) and warm ($P < 0.05$) periods as well as for the whole year ($P < 0.0001$). For acute patients, the yearly average shows also a significant correlation with weather situations of prevailing slight wind speed ($P < 0.05$) and high barometric pressure ($P < 0.05$), but these characteristics are not yet significant for the 3-day series in the cold and warm parts of the year.

Even more meaningful correlations have been obtained for the 5-day moving series (Table 6) between the frequency of chronic patient disturbances and high temperatures in the cold part ($P < 0.0001$), and low temperatures in the warm ($P < 0.0001$) part of the year; and between the frequency of acute patients and high relative humidity in the cold part ($P < 0.0001$) and somewhat less significant in the warm ($P < 0.05$) part of the year. High relative humidity ($P=0.0001$) appears to be a significant factor with chronic patients (similar to the 3-day series) along with low temperature in the warm part of the year. The five-day situations with light wind are significant for acute patients in the cold part of the year ($P < 0.05$) as well as in the year as a whole ($P < 0.01$); the same applies to low barometric pressure in the cold part of the year ($P < 0.01$) for chronic patients and to high barometric pressure in both the cold part of the year ($P < 0.05$), and the whole year ($P < 0.01$), for acute patients.

The 7-day moving series (Table 7) highlight even more the connection between health adversities in chronic patients and high air temperatures in the cold ($P < 0.0001$) part of the year and low temperatures in the warm part ($P < 0.0001$); and acute patient complications connected with high humidity both in the cold ($P < 0.0001$) as in the warm ($P < 0.05$) part of the year. For the first time a significant correlation has been noticed between low air temperature in the warm part of the year ($P < 0.05$) and the 7-day moving averages of acute disease frequency. The 7-day moving periods also indicate a significant link between both chronic ($P < 0.05$) and acute ($P < 0.05$) diseases and light wind in the cold part and in the whole year, although in the warm part of the year there are no significant relations. Only in the cold part of the year, and in the year as a whole, there is a significant relationship between barometric pressure and chronic and acute respiratory diseases, only of opposite signs. The situations with low barometric pressure ($P < 0.001$) are significant for chronic patients and those with high barometric pressure for acute patients ($P < 0.05$).

4.4. A CORRELATION BETWEEN THE SINO-BRONCHIAL SYNDROME, SO_2 AND SMOKE CONCENTRATION

SO_2 and smoke concentration was measured in the small park of the Meteorological and Hydrological Service situated on Grič hill, in the center of the town, at 150 m ASL, away from the main industrial zone. At the same time, this position is about 30 m above the main town streets with dense traffic and above the territory where the observed children live. Analyses were performed by the West-Gaeke spectrophotometric method. The maximum 24-hour concentration registered at this locality in the studied period from 1988–90 was only 148 μgm^{-3} of SO_2, and 260 μgm^{-3} of smoke. There was a number of days when only 0 μgm^{-3} of both was registered. The data of the Institute for Medical Research and Work Medicine, which has 9 representative points throughout the town for measuring SO_2 and smoke concentration (according to the acidimetric method), could have been more helpful for this study but they, unfortunately, were not available. We, therefore, used the chemical data of the Meteorological Service, keeping in mind that only their trend and relative relations may be useful.

Table 8. Significant correlation coefficients between 24-hour concentrations of SO_2 and smoke at Grič and the chronic sino-bronchial syndrome and acute respiratory diseases; also between SO_2 and smoke concentrations and the bioclimatic sensation *i/H*; for 1-, 3-, 5- and 7-day moving periods in Zagreb

Tablica 8. Signifikantni korelacijski koeficijenti između 24-satnih koncentracija SO_2 te dima i kroničnog sino-bronhalnog sindroma te akutne respiratorne bolesti; također između koncentracija SO_2 te dima i bioklimatskog osjeta *i/H*; za 1-, 3-, 5- i 7-dnevne klizne periode u Zagrebu

		COLD PART OF THE YEAR						WARM PART OF THE YEAR					
		SO_2			SMOKE			SO_2			SMOKE		
		Chronic	Acute	*i/H*	Chronic	Acute	*i/H*	Chronic	Acute	*i/H*	Chronic	Acute	*i/H*
	r			0.35	–0.10					–0.24			
1–day	*n*			537	537					542			
	P			0.00	0.02					0.00			
	r	–0.14		–0.44	–0.19		–0.13			–0.33		0.10	–0.17
3–day	*n*	537		537	537		537			542		542	542
	P	0.00		0.00	0.00		0.00			0.00		0.02	0.00
	r	–0.18		–0.49	–0.26					–0.38		0.16	–0.22
5–day	*n*	537		537	537		537			542		542	542
	P	0.00		0.00	0.00		0.00			0.00		0.00	0.00
	r	–0.20		–0.52	–0.29		–0.21			–0.42		0.15	–0.26
7–day	*n*	537		537	537		537			542		542	542
	P	0.00		0.00	0.00		0.00			0.00		0.00	0.00

r - correlation coefficient *P* - significance level *n* - number of cases

The results show that only the correlations between SO_2, or smoke, and the chronic sino-bronchial syndrome are significant in the cold part of the year (Table 8); while in the warm part of the year only the correlations of smoke and acute disease are significant. A negative sign of the obtained linear correlation coefficients would suggest that the chronic sino-bronchial syndrome increases in the studied 1-, 3-, 5-, and 7-day periods if SO_2 and smoke concentrations decrease which can not be accepted. The significant correlation of SO_2 and smoke with the biometeorological index *i/H* in the cold part of the year is, therefore, more probable and logical revealing smaller concentrations of SO_2 and smoke as the periods are warmer. Such results enable us to conclude that only the meteorological conditions were related to the incidence of the sino-bronchial syndrome in Zagreb.

In the warm part of the year, according to the significant correlation coefficients, the contribution of increased smoke concentrations to more frequent acute diseases may not be excluded (along with a few-day period of cooling). Such relation is probably valid primarily for spring and autumn because the warmer part of the year includes all months from April to September.

5. CONCLUSION

The results of our study correspond to the conclusions for asthma quoted by Tromp and others. With regard to the method applied, our results further clarify the difference between the warm and cold parts of the year and between the chronic and acute disease incidence. Therefore it may be concluded for:

– The chronic sino-bronchial syndrome:

1. Chronic patients have a lower sensibility threshold and their response to meteorological stress is faster. A probable explanation for such an assertion can be found in the reality that the mucous membrane of the respiratory tract of children and adolescent suffering from the chronic sino-bronchial syndrome is damaged - no matter whether the damage has been acquired through repeated acute inflammations or is genetically stipulated as damaged cilias (Kolbas, 1982).

2. Cold periods in the warm part of the year (April-September) seem to be more significant than warm periods in the cold part of the year (October to March) because the latter become significant only if they last three days or more.

3. Cold periods in the warm part of the year, and warm periods in the cold part of the year as indicated

by thermal sensation (determined by means of the bioclimatic index), are the more significantly correlated to the chronic sino-bronchial syndrome frequency the longer they persist.

4. With regard to a single meteorological element (air temperature, relative humidity, wind speed, barometric pressure), a significant increase in the incidence of the chronic sino-bronchial syndrome in the warm part of the year coincides with periods of low temperature and high relative humidity, while in the cold part of the year it coincides with periods of high air temperature and low barometric pressure. The significance of the correlation increases as well with the span of such periods.

5. The highest conditional probability of the occurrence of the chronic sino-bronchial syndrome with definite thermal sensation in the cold part of the year is first in the "comfortable" and then in the "cool" days.

6. In the warm part of the year, the chronic sino-bronchial syndrome occurrs with the highest conditional probability in the "cool" and "cold" days, and then in the "comfortable" days.

– An acute disease of the upper and lower respiratory tracts:

1. Acute diseases are significantly more frequent primarily in weather situations with high relative humidity in both the warm and cold parts of the year if periods with high relative humidity last at least three days. The important characteristics of such periods, longer than three days in the cold part of the year, are low wind speed and high barometric pressure together with high relative humidity. These circumstances are often favourable for the formation of radiation fog, the correlation of which with the incidence of the sino-bronchial syndrome will be investigated next. Low air temperatures in the warm part of the year are important for acute disease occurrences but only if they last seven days or more.

2. A significant correlation between acute disease incidence and thermal sensation (bioclimatic index) has been obtained only for warm periods lasting at least seven days in the cold part of the year. These results are similar to Ayres (1988) whose results for the United Kingdom indicate more frequent acute respiratory diseases in the cold winter months.

3. The highest conditional probability for acute respiratory diseases in the warm part of the year is only for days classified as "sultry" and "dangerously warm" .

4. In the cold part of the year, the highest conditional probability for acute respiratory diseases is for days categorized as "comfortable" and "warm".

– Air pollution:

1. SO_2 and smoke pollution in the three years considered has not been significant neither for chronic nor for acute disease occurrence. Concentrations, according to MHSC measurements, were within law permitted limits.

Acknowledgement: This research is based on the project supported by the Croatian Science Foundation (No. 3-01-115).

REFERENCES:

Ayres J. G., 1986: Seasonal pattern of acute bronchitis in general practice in the United Kingdom 1976–83, *Thorax* **41**, 106–110.

Böer W., 1964: Tehnische Meteorologie, Teubner Verlags gesellschaft, Leipzig, 290.

Conrad V., L.W. Pollak, 1950: Methods in Climatology, Cambridge.

Islam M. S. und H. W. Schlipköter, 1993: Lungenfunktion und Luftverunreinigung, *Atmw-Lungencrkh.*, Jahrgang **19**, No.4, 139–144.

Katzschner L.,1990: Atemwegserkrankungen in Abhängigkeit von Klima, Luftblastung und Stadtstrukturen, *Ost Gesundh.-Wes.* **52**, 14–21.

Kolbas V., 1982: Alergologija dječje dobi, *JUMENA*, Zagreb, 72–77.

Krstić-Burić M., N. Pleško, B. Momčilović, M. Bašić-Grbac, M. Medar-Lasić, D. Milković, M. Šumić, 1991: Sino-Bronchial Syndrome in a Children Population of an Industrialized Urban Area, Lung and Environment, *8 Congress of Pneumology,* Trieste – Italy, November 8–9, 1991, Alpe – Adria – Pannonia, 57–58.

Landsberg H.E., 1972: The Assessment of Human Bioclimate, WMO, *Tech. Note* No.**123**, 36.

Milleron B., H. Liote, J. Lacau Sain Guilly, A.de Statenrath and G. Akrun: Sinus pathology and respiratory tract disease, *Rhinology*, Suppl.**4**, 13–19.

Novaković, J., 1983: Vjerojatnost pojava i trajanja različitog toplinskog osjeta u Zagrebu tokom 1981, *Rasprave RHMZ SRH*, **18**, 29–40.

Pleško N., 1979: Turističko-zdravstveni aspekt klimatskih prilika na Jadranu, *Druga konferencija o zaštiti Jadrana, Zbornik referata*, Hvar, 1979, 203–213.

Pleško N., 1983: Biometeorološki indeksi u ocjeni termičkog komfora Zagreba za vrijeme različitih sinoptičkih situacija, *Rasprave RHMZ SRH*, **18,** 1983, 3–16.

Tromp S.W., 1963: Medical Biometeorology, Elsevier, Amsterdam, 991. pp.

Tromp S.W., 1980: Biometeorology, Heyden, London, 346. pp.

Vukelić B. und N.Pleško, 1990: Der Einfluß von Maritimen Umweltfaktoren auf den Verlauf des Bronchialasthmas in Kindesalter – Ergebnisse nach einjähriger Beobachtung, *Zeitschrift für Klinische Medizin*, Band **45,** Heft 20.