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THE INFLUENCE OF BIOMETEOROLOGICAL PARAMETERS ON THE INFECTIOUS RESPIRATORY DISEASES IN ATHENS, GREECE

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1. INDRODUCTION

It is well known from the era of Hippocrates (430 BC) that meteorological changes influence the human health. The effect of weather changes, and also the atmospheric environment in general, on humans' health has been studied by numerous scientists (Katsouyanni et al., 1988; Kalkstein, 1993; Colwell et al., 1998; Panagiotakos et al., 2004; Bartzokas et al., 2003). More specifically, an estimate of the likely influence of certain weather types or specified thresholds of meteorological variables on human health appeared to be very important.

Also, IPCC highlights (Technical Summary, 2001) that global climate change will have various impacts on human health; some of which are positive, but mostly negative. Changes in the frequencies of extreme heat and cold, the frequencies of floods and droughts, and the profile of local air pollution and aeroallergens would directly affect population health. Possible quantitative effects of meteorological and biometeorological parameters on the emergence of Infectious Respiratory Diseases (IRD) in the wider region of Athens are investigated.

2. METHODS

The medical data used in this study, concerning 1212 recordings of patients who suffered from IRD, was documented by the Local Health Unit of the Institution of Social Insurances in Acharnes city in the Northwest suburbs of Athens, Greece, during the year 2002. IRD includes the following diseases: bronchitis, tracheiobronchitis, respiratory infections, farygitis, tonsillitis, laryngitis, the common cold and flu, and pneumonia. The analysed meteorological data which were recorded by the meteorological station of the National Observatory of Athens, include the following parameters: mean air temperature, maximum air temperature, minimum air temperature, daily air temperature range, day-to-day change in mean air temperature, day-to-day change in maximum air temperature, day-to-day change in minimum air temperature, relative humidity, day-to-day change in relative humidity, absolute humidity, day-to-day change in absolute humidity, sunshine, day-to-day change in sunshine, atmospheric pressure and day-to-day change in atmospheric pressure. The following biometeorological parameters were also evaluated: Mean Radiant Temperature (T_{mrt}), Predicted Mean Vote (PMV), Physiologically Equivalent Temperature (PET) and Standard Effective Temperature (SET*) as well as their day-to-day changes (Matzarakis et al., 2004). The relative humidity reveals the percentage of saturation of water vapors in the atmosphere and not the total sum of water vapors contained in it. The vapor pressure is considered as the most important parameter for the estimation of the effect of humidity on the human body (Fiedler, 1989).

The relationship between IRD and the aforementioned meteorological 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 with Poisson distribution (GLM). As a first step of the detailed statistical analysis, the values of each meteorological and biometeorological parameter were grouped in five quintiles, so that the first quintile contained the lowest 20% and the fifth quintile the highest 20% of all values. In this process, the number of days with 0, 1, 2, 3, 4 and 5 or more events of IRD in the Health Unit was calculated for each quintile. The results of this step were assembled in, a contingency table for every parameter. Tables 1 presents the contingency tables for mean air temperature, absolute humidity, PET and ΔPET. The Pearson χ^2 test was applied for each of the 23 contingency tables, testing the null hypothesis that the quintiles of each meteorological parameter are not related (hence they are independent) to the number of IRD. The use of contingency tables instead of Pearson correlation considered to be more accurate, since the medical data show a high dissimilarity to a Gaussian (regular) distribution. In the second step of the performed analysis, the statistical importance of the correlation between the frequency of IRD and the meteorological parameters was examined by the application of Generalized Linear Models (GLM) with Poisson

Table 1. Number of days with 0, 1, 2, 3, 4 and 5 or more cases of IRD in the Health Unit for each quintile of the mean air temperature (T), absolute humidity (e), physiological equivalent temperature (PET) and day-to-day changes in physiological equivalent temperature (ΔPET).

Quintiles T (^{o}C)		**Cases of Infectious Respiratory Diseases**					
		0	**1**	**2**	**3**	**4**	**≥5**
1	T≤12.5	36	7	1	5	3	23
2	12.5<T≤16.1	25	4	2	2	5	34
3	16.1<T≤21.4	27	4	2	8	7	26
4	21.4<T≤26.1	29	5	6	6	8	17
5	T>26.1	37	5	3	7	3	18

Quintiles of e (g m^{-3})		**Cases of Infectious Respiratory Diseases**					
		0	**1**	**2**	**3**	**4**	**≥5**
1	e≤7.6	33	9		4	3	24
2	7.6<e≤9.2	28	2	1	5	5	33
3	9.2<e≤11.2	33	4	5	3	5	22
4	11.2<e≤13.5	26	6	2	12	4	23
5	e>13.5	34	4	6	4	9	16

Quintiles of PET (^{o}C)		**Cases of Infectious Respiratory Diseases**					
		0	**1**	**2**	**3**	**4**	**≥5**
1	PET≤11.8	36	7	1	5	3	21
2	11.8<PET≤16.7	28	4	2	3	6	30
3	16.7<PET≤23.2	25	4	2	6	4	32
4	23.2<PET≤29.4	27	5	6	9	10	17
5	PET>29.4	38	5	3	5	3	18

Quintiles ΔPET (^{o}C)		**Cases of Infectious Respiratory Diseases**					
		0	**1**	**2**	**3**	**4**	**≥5**
1	ΔPET≤-1.8	30	6	2	6	3	27
2	-1.8< ΔPET ≤-0.5	34	3	3	8	8	19
3	-0.5< ΔPET ≤0.8	35	9	1	9	4	25
4	0.8< ΔPET ≤1.9	34	2	4	4	5	14
5	ΔPET >1.9	21	5	4	1	6	33

distribution described by McGullagh and Nelder (1997). In the models fitting procedure we used as dependent variable the daily number of outpatients with IRD symptoms that were sent to the Local Health Unit of the Institution of Social Insurances in Acharnes city, while as independent covariates the aforementioned meteorological and biometeorological parameters were included. Models' goodness-of-fit was evaluated through deviance residuals (McGullagh and Nelder 1997).

3. RESULTS AND DISCUSSION

The monthly distribution of the number of IRD for the year 2002 is presented in Figure 1, where the maximum number of recorded IRD is marked in April and the minimum in August. The period from January to April is characterised by an increased number of episodes IRD. The application of Pearson χ^2 test to the 23 contingency tables of the meteorological parameters showed, that a statistically significant correlation (confidence level 95%) between the number of IRD, the absolute humidity, and the day-to-day change in atmospheric pressure exists. Danielides et al (2002) gained similar results from their study of the effect of meteorological parameters on the acute laryngitis for the region of Ioannina, Epirus-Greece during a five-year period 1995-1999. The number of cases of IRD seems to be higher during the negative changes of the atmospheric pressure (first quintiles of the contingency table). Such changes usually take place during the winter, as the low barometric systems approaches Greece from the west and resulting in less appealing weather conditions. Also, there is a statistically significant correlation (confidence level 90%) between the daily number of IRD, the maximum air temperature and the day-to-day change in sunshine. More precisely, an increase of the maximum air temperature and the sunshine values results in a decrease of the daily number of IRD. Concerning the biometeorological parameters, a statistically significant relationship (confidence level 95%) exists between the daily number of IRD and the day-to-day changes in T_{mrt}, while with a lower confidence level (90%), a significant correlation exists between IRD, PET, ΔPET and ΔSET.

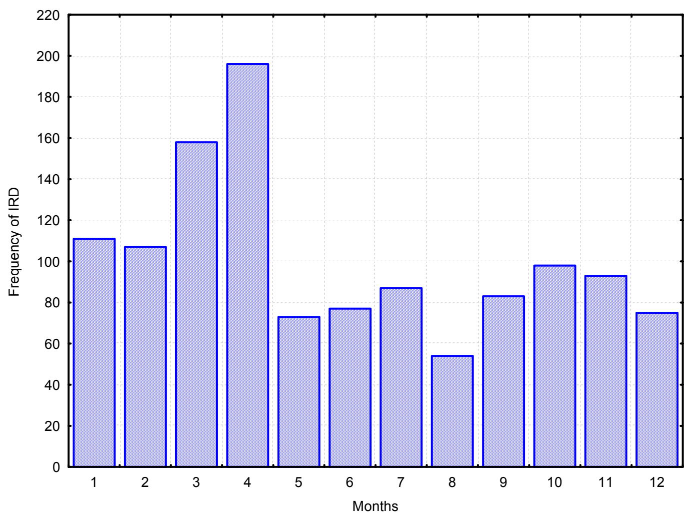

Figure1. Monthly distribution of the number of Infectious Respiratory Diseases for the year 2002.

Table 2. Results of the application of Generalized Linear Models (GLM) with Poisson distribution, (dependent variable is the daily number of outpatients with IRD symptoms, while independent covariates are the aforementioned meteorological and biometeorological parameters).

variable	b coefficient ± standard error	significance level p	variable	b coefficient ± standard error	significance level p
T_{mean} (^oC)	-0.0198±0,0043	0.000004	T_{mrt} (^oC)	-0.0107±0.0032	0.000995
T_{max} (^oC)	-0.0157±0,0038	0.000035	PMV	-0.0636±0.0158	0.000054
T_{min} (^oC)	-0.0228±0,0047	0.000001	PET (^oC)	-0.0134±0.0032	0.000029
T_{range} (^oC)	-0.0044±0,0117	0.708669	SET* (^oC)	-0.0122±0.0036	0.000714
ΔT (^oC)	-0.0051±0,0194	0.792489	ΔT_{mrt} (^oC)	0.0293±0.0140	0.036668
ΔT_{max} (^oC)	-0.0039±0,0125	0.753191	ΔPMV	0.1096±0.0607	0.110926
ΔT_{min} (^oC)	0.0185±0,0175	0.290997	ΔPET (^oC)	0.0189±0.0119	0.070945
RH (%)	0.0026±0,0021	0.204845	ΔSET (^oC)	0.0226±0.0115	0.050114
ΔRH (%)	0.0093±0,0032	0.004096			
e ($gr.m^{-3}$)	-0.0449±0,0092	0.000001			
Δe ($gr.m^{-3}$)	0.0372±0,0191	0.052247			
S (hours)	-0.0024±0,0070	0.727909			
ΔS (hours	0.0014±0,0082	0.859683			
P (hPa)	-0.0023±0,0052	0.663452			
ΔP (hPa)	-0.0072±0,0088	0.414669			

The results of the application of Generalized Linear Models (GLM) are presented in Table 2. The interpretation of the findings leads to the conclusion that a statistically significant correlation ($p<0.05$)

exists between the number of cases of IRD and the mean temperature, the maximum temperature, the minimum temperature, the absolute humidity, as well as the day-to-day changes in the relative and absolute humidity. A decrease of 10 °C in mean daily air temperature leads to an increase of 20% in the probability of people suffering from IRD, while a decrease of 10 °C in maximum air temperature is related to an increase of 16% in the probability of the appearance of IRD, and finally a decrease of 10 °C in minimum temperature links to an increase of 23% in the probability of having an event of IRD. The analysis of the effect of relative humidity shows that an increase of 10% in day-to-day changes is related to an 9% increase in the probability of IRD. It is worth to be noted that an increase of 10 g/m^3 in absolute humidity leads to a 45% decrease in the probability of the appearance of IRD and vice versa.

Taking into account the influence of the biometeorological regime, it was found that a statistically significant correlation ($p<0.05$) appears between the number of appearance of IRD and T_{mrt}, PMV, PET, SET*, as well as the day-to-day changes in ΔT_{mrt} and ΔSET*. A decrease of 10 °C in T_{mrt} leads to an increase of 11% in the probability of having an episode of IRD, while a decrease of 10 units in PMV is related to an increase of 62% in the probability of the appearance of IRD. Also, a decrease of 10 °C in PET, SET links to an increase of 13% and 12% in the probability of having an event of IRD. In addition, an increase of 10 °C in ΔT_{mrt} and ΔSET results in an increase of 29% and 22% in the probability of having an episode of IRD.

4. CONCLUSIONS

The analysis provides clear evidence that variations in weather, as they are presented in the changes of the 23 examined parameters, influence the number of cases of Infectious Respiratory Diseases in the wider region of Athens. More precisely, the air temperature and humidity parameters have the highest influence on the variability of the number of IRD. The application of Generalized Linear Models showed that not only the pure meteorological parameters but also the thermal indices provided by human-biometeorological methods explain the existing relationship between respiratory diseases and weather more clearly.

REFERENCES

Bartzokas, A., Kassomenos, P., Petrakis, M., Celessides, C., 2003: The Effect of meteorological and pollution parameters on the frequency of hospital admissions for cardiovascular and respiratory problems in Athens, Indoor and Built Environ, 13: 271-275.

Colwell, R.R., Epstein, P.R., Gubler, D., Maynard, N., McMichael, A.J., Patz, J.A., Sack, R.B., Shope, R., 1998: Climate change and human health, Science, 13, 279(5353): 968-969.

Danielides, V., Nousia, C.S., Patrikakos, G. Bartzokas, A., Lolis, C., Milionis, H.J, Skevas, A., 2002: Effect of meteorological parameters on acute laryngitis on adults, Acta Otolaryngol, 122: 655-660.

Fiedler, C.P., 1989: Effect of weather conditions on acute laryngotraxheitis, J. Laryngol Otol, 103: 187-190.

IPCC, 2001: Climate Change 2001: Impacts, Adaptation and Vulnerability. Technical Summary.

Kalkstein, L.S., 1993: Health and climate change. Direct impacts in cities, Lancet, 4, 342(8884): 1397-1399.

Katsouyanni, K., Trichopoulos, D., Zavitsanos, X., Touloumi, G., 1988: The Athens heat wave, Lancet, 3: 573.

Matzarakis, A., Rutz, F. and Mayer, H., 2000: Estimation and calculation of the mean radiant temperature within urban structures. WCASP-50, WMO/TD, No. 1026: 273-278

McGullagh, P., Nelder, J.A., 1997: Generalized Linear Models, 2nd Edition, Chapman & Hall, pp. 450.

Panagiotakos, D.B., Chrysohoou, C., Pitsavos, C., Nastos, P.T., Anadiotis, A., Tendolouris, C., Stefanadis, C., Toutouzas, P., Paliatsos, A., 2004: Climatological variations in daily hospital admissions for acute coronary syndromes, Int. J. Cardiology, 94: 229-233.