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THE TEMPORARY IMPACT OF EXTREME TEMPERATURE ON EMERGENCY ROOM VISITS IN SARAJEVO DURING THE SUMMER 2012 HEAT WAVES

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Abstract- Introduction: ***A major cause of weather-related deaths is increased frequency and intensity of heat waves, especially in urban areas because of a heat island effects. The negative impacts of the heat waves in urban areas can be exacerbate by trapped pollutants in the stagnant atmospheric conditions. Up to now the effect on morbidity of high temperature modified by air pollutants has not been evaluated in Bosnia and Herzegovina. The purpose of this study is to assess the temporary impact of extreme temperature associated with air pollution levels on emergency room visits during the Summer 2012 heat way.***
Methods: ***Day was the statistical unit in this an ecologic study of the relation between ER visits and environment condition. ER patients list were used to collect date of EMACS admissions. Meteorological and air pollution date were obtain by FHI. Statistical analyses were performed using the Statistical Package for Social Sciences software (version 13.0).***
Results: ***During the extremely hot days the most frequent health disorders were gastrointestinal (22.71%), cardiovascular (22.23%) and neuropsychiatric disorders (18.23%). There was a significant positive correlation between the values of maximum daily temperature and urological ($p<0.01$) admissions, relative humidity of air and cardiovascular ($p<0.05$) and neuropsychiatric ($p<0.05$) admission, and between the concentration of PM_{10} and neuropsychiatric ($p<0.05$) admission.***
Conclusion: ***Air quality during the heat waves may influence on ER visits in urban areas what should be considered by health relevant sectors.***

Keywords **-** health disorders, air quality, increasing heat load
Abbreviations: ER- emergency room; EMACS - Emergency medical assistance of canton Sarajevo; FHI - Federal Hydrometeorological Institute; WMO - World Meteorological Organization

I. INTRODUCTION

Human health is threaten by climate change directly through increased extreme weather events, decreased air quality, and infectious diseases, particularly food-, water-, and vector- borne diseases [1]. Of all adverse weather conditions heat waves have the greatest influence on lifestyle, human comfort, and human health [2]. Heat waves can be defined as episodes with a sustained heat load that affect human health [3].

Heat waves, defined by the WMO, are periods of five or more days when temperatures exceed the average maximum (in the years from 1961 to 1990) by 5 °C [4]. A heat wave includes the combination of intensity and duration of high temperature periods what depend on the type of climate in a particular area. In temperate climate zone an extended period of heat is categorized as a heat wave when the maximum temperature reached 32°C or above for three consecutive days [5].

Regional climates depend on land use. An urban area generates and sustains heat as result of buildings with lower wind velocities, low reflectivity of black asphalt and other dark surfaces such as roofs, and lack in vegetation and trees associated with the less evapotranspiration cooling. Industrial activities increase creation of radiation. All of this is associated with nocturnally sustained—temperatures. The health outcomes during heat waves depend on heat intensity, duration, repetition, time between adjacent events. Vulnerability of people in cities can be increased by elevated pollution levels often accompany heat waves [1]. In Sarajevo motor vehicle exhaust emission is primarily source of air pollution.

The purpose of this study is to assess the temporary impact of extreme temperature associated with air pollution levels on ER visits during the Summer 2012 heat wave.

To our best knowledge, such approach has not been applied elsewhere in Bosnia and Herzegovina. Findings could help to manage emergency departments and preventive programs.

II. METHODS

Design

The study was designed as a retrospective cross-sectional survey conducted at the EMACS. Health disorders analyze was done in a sample of 1048 patients treated in ER of EMACS during extremely hot days of Jun, July and August 2012.

Sources of date

Meteorological and Air Quality Data

Daily meteorological records and air pollution monitoring records were obtained from the FHMZ.

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Weather monitoring station provided 24-hour weather data (maximum temperature, minimum temperature, relative humidity, wind speed, and barometric pressure). There was missing value for wind speed for 9. July. Average value of relative humidity, wind speed, and barometric pressure was used, and mean daily temperature was calculated using equation:

$T=(t_7+t_{14}+2xt_{21})/4$

where: t_7- temperature measured at 7; t_{14}- temperature measured at 14; t_{21}- temperature measured at 21.

Concentrations of ambient air pollutants, such as particulate matters less than 10 mm in aerodynamic diameter (PM_{10}), carbon monoxide (CO), and sulfur dioxide (SO_2), were determined and recorded hourly at station Bjelave. There were no missing values.

Morbidity Data

From the EMACS' ER patients lists the admissions dataset was obtained containing patient protocol number, information on gender, birth date, and physicians' diagnoses. The focus was on the causes that are suspected to respond to high temperatures from the health perspective. Excluded diagnosis from this research were: intoxication, birth delivery, injury (accident and insect-,animal- bite), palliative care for oncology patients, blood pressure control and regular therapy. Emergency ambulance dispatches were not included.

Statistics

Data is presented by using means and SDs (for numerical variables), and frequencies and percentages (for categorical variables). Differences between numerical variables were tested by using an independent t test and between categorical variables were tested by using Kruskal Walisov test. Correlation between variables was assessed by Pearson correlation coefficient, which ranges from -1 to +1, representing a perfectly negative linear correlation and a perfectly positive linear correlation, respectively. Statistical analysis was performed using SPSS (version 13.0).

III.RESULTS

METEOROLOGICAL HEAT WAVE CHARACTERISTICS

In this study morbidity analysis was done for 10 extremely hot days:

- 20th and 21st June (34.3°C and 34.5°C, respectively)
- 1st, 2nd, 9th and 29th July (36.9°C, 36.4°C, 36.2°C and 37.0°C, respectively)
- 6th, 7th, 22nd and 23rd August (38.3°C, 37.1°C, 37.1°C and 37.2°C, respectively)

These days were selected as part of five heat waves occurred in Sarajevo during summer 2012. First heat wave lasted 6 days (June 17-22) with temperatures maximum 32.1-34.5°C, minimum 13.7-17.8°C. Second heat wave lasted 14 days (June 29 to July12) with temperatures maximum 32.7-36.9°C, minimum 14.7-19.3°C. Third heat wave lasted 3 days (July 28-30) with temperatures maximum 32.0-37.0°C, minimum 15.6-17.7°C. Fourth heat wave lasted 7 days (August 2-8) with temperatures maximum 32.9-38.3°C, minimum 15.1-19.6°C. Fifth heat wave lasted 7 days (August 20-26), with temperatures maximum 34.4-37.2°C, and minimum temperatures 13.1-16.7°C. All heat waves fulfilled requirement from the definition of a heat wave given by the WMO in terms of the temperature threshold, i.e., all temperatures maximum were at least 5°C higher than 1961-990. monthly average (June – 23.3°C, July – 25.5ºC, August – 25.7°C).

Heat wave related morbidity

Gender and age characteristics of the patients treated in EMACS

In present study 1048 patients were included. There were 452 (43.13%) males and 596 (56.87%) females. Mean age of all patients was 45.14±18.07. Maximum was 103 year, and minimum was 1 year. Mean age of male patients was 46.53±17.74 years. Mean age of female patients was 44.09±18.26 years. A independent t test showed no significant difference in age structure between gender (p=0.311).

Daily admission distribution

Chart 1 shows daily admission of patients in certain intervals of extremely hot days.

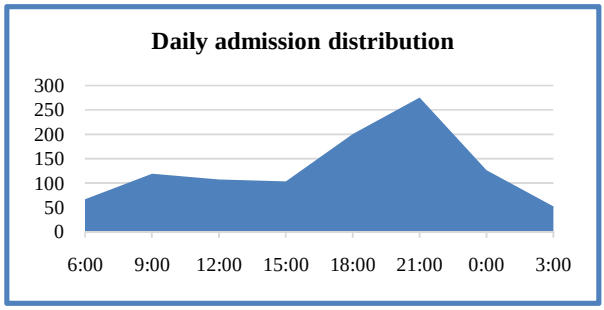

Chart 1. Daily admission of patients in 3 hours intervals

The most patients (45.32%) were admitted at evening, 18:00-23:59.

Health disorders in patients sample

Mean health problems at patients treated during the extremely hot days in the EMACS' ER were stratified into nine groups.

During the extremely hot days the most frequent health disorders were gastrointestinal (22.71%), cardiovascular (22.23%), and neuropsychiatric disorders (18.23%). Others were less frequent: myalgia with arthralgia (10.78), allergy (10.21%), urological disorders (7.25), respiratory disorders (3.91), gynecological disorders (2.86), and febricity (1.82).

Weather and Climate Effects on Disease Background Levels

Effects of meteorological parameters (Table I) and air pollutants (Table II) on health disorders were analyzed through Pearson's correlation.

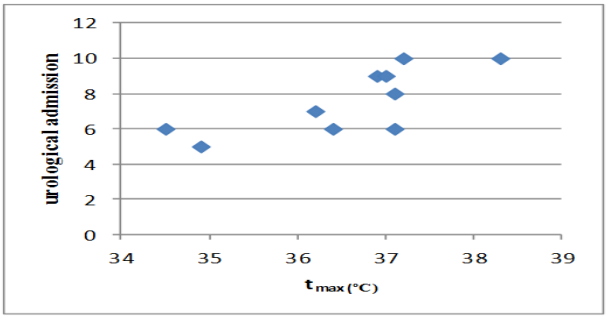

Chart 2. Correlation between maximum temperature and urological admission

TABLE I Pearson's correlation coefficients between mean health problems and meteorological parameters (*p<0,05; **p<0,01)

Mean health disorder	Meteorological parameters				
	Maximum temp. (°C)	Relative humidity (%)	Barometric pressure (hPa)	Wind speed (m/s)	Wind direction
Total	-0.009	0.379	-0.269	0.330	-0.226
Cardiovascular	-0.527	0.636*	-0.432	-0.185	-0.423
Gastrointestinal	0.557	-0.300	0.396	0.194	0.493
Allergy	0.049	-0.036	-0.154	0.545	-0.194
Myalgia. arthralgia	0.260	0.110	-0.181	0.559	-0.118
Neuropsychiatric	-0.393	0.664*	-0.573	0.146	0.212
Gynecological	-0.127	0.433	-0.311	0.272	-0.214
Urological	0.771**	-0.448	0.209	0.561	0.098
Febricity	0.638	-0.422	0.019	0.464	0.194
Respiratory	-0.410	0.373	0.093	-0.391	-0.215

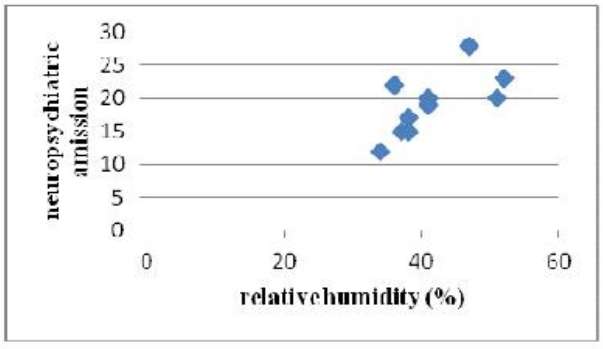

Chart 3. Correlation between relative humidity and neuropsychiatric admission

TABLE III Pearson's correlation coefficients between mean health problems and air pollutants (*p<0,05; **p<0,01)

Mean health disorder	Air pollutants			
	SO_2 ($\mu g/m^3$)	Black smoke ($\mu g/m^3$)	CO ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)
Total	0.389	0.075	-0.559	0.319
Cardiovascular	0.572	0.314	-0.417	0.342
Gastrointestinal	-0.253	-0.178	0.215	0.174
Allergy	0.261	0.075	-0.557	-0.319
Myalgia. arthralgia	0.267	-0.233	-0.546	0.050
Neuropsychiatric	0.227	0.210	-0.148	0.748*
Gynecological	0.187	0.212	-0.550	0.340
Urological	-0.245	-0.122	0.129	-0.413
Febricity	-0.248	0.263	-0.198	-0.499
Respiratory	0.347	-0.279	-0.065	0.283

The maximum temperature (Chart 2) significantly positively correlated with admission of patients with urological disorders (rho=0.771, p<0.01).

Relative air humidity (Chart 3 and 4) significantly positively correlated with admission of patients with cardiovascular (rho=0.636, p<0.05) and neuropsychiatric disorders (rho =0.664, p<0.05).

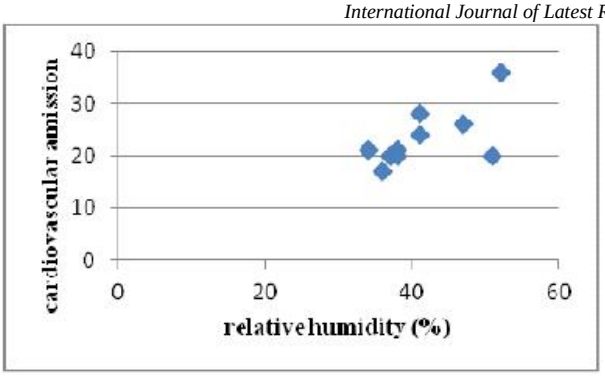

Chart 4. Correlation between relative humidity and cardiovascular admission

The concentration of PM_{10} (Chart 5) significantly positively correlated with admission of patients with neuropsychiatric disorders (rho=0,748, p<0,05).

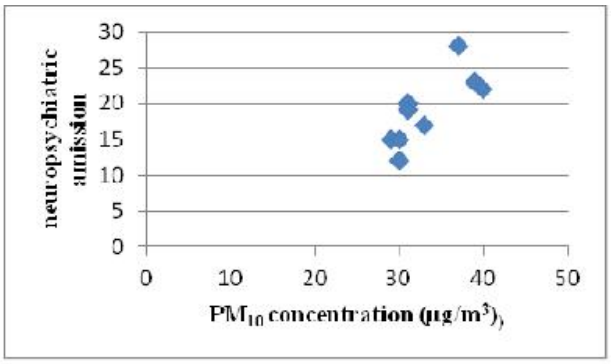

Chart 5. Correlation between PM_{10} concentration and neuropsychiatric admission

IV. DISCUSSION

The purpose of this study is to assess the temporary impact of extreme temperature associated with air pollution levels on ER visits during the Summer 2012 heat wave. Numerous heat waves affected Europe in the 2012. In Bosnia and Herzegovina total duration of heat waves was 40 days with maximum daily temperature 32°C and more. In this study ten extremely hot days were selected to evaluate effect of air pollutant and weather parameters on health in sample of 1048 patients. Mean age of all patients was 45.14±18.07. These findings are similar to results from Shanghai study with expressed susceptible to variability of ambient temperature of occupational population [6]. The most patients (45.32%) were admitted at evening, between 18:00-23:59, what could be explained by excluding emergency ambulance dispatches from study.

Every change in the weather (air temperature, relative humidity, barometric pressure, air velocity, etc.), leads to changes in metabolism and acid-base balance, which is held on the function of the autonomic nervous system, blood circulation and body temperature. Chronic patients have trouble adapting to changed weather conditions, and their existing symptoms exacerbate. During heat waves hospital admissions are increased for adults as well as for the elderly, for classical heat illnesses (heat stroke and heat exhaustion) and for related conditions (dehydration), neurological conditions, renal and mental illness [7]. In this study during the extremely hot days the most frequent health disorders were gastrointestinal (22.71%), cardiovascular (22.23%) and neuropsychiatric disorders (18.23%). The increase in hospital admissions because flares of inflammatory bowel disease and infectious gastroenteritis during heat wave periods was shown in the retrospective controlled observational study conducted in the University Hospital of Zurich [8]. Individuals older than 65 year comprised most of the extra emergency room visits and deaths during heat waves [9]. In period May–September from 1995 to 2007 there were statistically significant increases in emergency department visits for mental and psychosocial problems in all age groups in Québec [10].

Ye et al reviewed 15 epidemiological studies published before 30 June 2010 that investigated the short-term effects of heat wave on morbidity. The majority of studies reported detrimental effects of heat on the same day or up to the following 3 days. Recognized inconsistencies in the temperature–morbidity relationship is associated with discrepancy between studies carried out in different world regions about air pollution role [11]. Sociodemographic factors may be confounded or modified heat wave health effects.

In this study different causes of emergency admissions were correlated with each single environment variable. The maximum temperature significantly positively correlated with admission of patients with urological disorders (rho=0.771, p<0.01). During periods of extreme heat, adaptation of the body can lead to stress for kidneys and compromise function of renal system [12].

Relative air humidity significantly positively correlated with admission of patients with cardiovascular (rho=0.636, p<0.05) and neuropsychiatric disorders (rho=0.664, p<0.05). Study that included four hospitals in Thai Nguyen province for a period of 5 years from 2008 to 2012 showed correlation between temperature and humidity, but there was no correlation between humidity and cardiovascular disease hospital admissions among elderly people [13]. Significant increases in emergency department visits for mental and psychosocial problems of those under age 65 followed higher humidity levels [10].

The concentration of PM_{10} significantly positively correlated with admission of patients with neuropsychiatric disorders (rho=0,748, p<0,05). Health impact of PM_{10} is due to observed moderate to high correlations with temperature [14]. Air pollution impact on mortality is much more evaluated then on morbidity. There are evidence that the effects of heat wave days on mortality are larger during high ozone days and high PM_{10} days, while such interaction is not estimated between heat wave days and the concentrations of NO_2, SO_2 and CO [15].

V. CONCLUSIONS

In Bosnia and Herzegovina there have been no population ecological studies of associations between emergency room visits and environment variables. Increasing frequency and severity of heat waves would followed with untoward health outcomes. The identification of those most susceptible to temperature extremes is important for public health.

LIMITATIONS

Caution should be exert in the interpretation the study's finding because following limitations: 1. it is based on the analysis of extremely hot days of one year heat episodes, 2. beside EMACS there are other emergency departments (in Clinical Center University of Sarajevo, and in The Public Institution Health Centre of Sarajevo Canton), and 3. atmospheric conditions associated with extremely high temperatures are usually accompanied by high concentrations of secondary pollutants that were not measured.

These limitations points there is need to form unique electronic register of EMACS and other emergency departments to have realistic date of heat waves consequences in region of Sarajevo.

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AUTHORS' CONTRIBUTIONS

Both authors equally contributed to the paper. SJP collected the emergency room visit data. AC analyzed the data. AC SJP wrote the paper.

Both authors have read and approved the final manuscript.

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