The influence of weather state on the incidence of preeclampsia and placental abruption in semi-arid areas

N.S. Yackerson[1], *Ph.D.*; **B. Piura**[2], *M.D., F.R.C.O.G.*; **M. Friger**[3], *Ph.D.*

[1]*Department of Electrical and Computer Engineering, Faculty of Technology*
[2]*Department of Obstetrics and Gynecology, Soroka Medical Center and Faculty of Health Sciences.*
[3]*Department of Epidemiology, Faculty of Health Sciences*
Ben-Gurion University of the Negev (BGU). Beer-Sheva (Israel)

Summary

Background: Being close to the big deserts of the Sahara and Saudi Arabia, the Negev desert in the south of Israel is meteorologically defined as a semi-arid area.

Purpose: To investigate the influence of meteorological factors typical for the semi-arid areas on the incidence of preeclampsia (PE) and placental abruption (PA).

Methods: The hospital records of women in confinement who had PE and/or PA between January 1, 1999 and December 31, 1999 were retrospectively reviewed. The current meteorological state was described by temperature, humidity, their overall differences and winds. Multivariate analysis, time series approach and Poisson regression are used.

Results: The incidence of PE and PA was increased during the periods of unstable weather. Strong winds were associated with increased frequency of PE ($p < 0.002$); desert wind of *Sharav* (specific atmospheric state and motion of big desert air volumes) increased incidence of PA ($p < 0.033$). Daily overall differences of temperature and humidity were correlated with PE ($p < 0.03$). An inverse correlation between humidity level and PA was obtained ($p = 0.000$). Increase in PE incidence preceded sharp variations in temperature with an average of 3-day lag ($p < 0.003$).

Conclusions: An ensemble of meteorological variables, specific for each disorder, affects frequency of *PA* and *PE* occurrence. Obstetricians working in semi-arid areas should be aware of the influence of unstable weather conditions on the incidence of PE and PA, especially, in the spring and autumn seasons.

Key words: Meteorological parameters; Placental abruption; Preeclampsia; Semi-arid areas; Winds.

Introduction

Emotional conflicts and multiform health disorders may be developed among the weather- sensitive people, perceiving several changes in their environment as a threat. This group contains about one-third of the Earth's population, in which the female fraction reaches up to 75% [1, 2]. Pregnancy constitutes a special susceptibility factor; the individual adaptive capability becomes weaker and responses to even small changes in habitual atmospheric environment would be much more acute than usual.

Pregnancy complications occur in many cases as a result of exacerbations of chronic problems due to extreme values of several meteorological parameters or weather perturbations [3-8], but some effects have not yet been confirmed by other authors [9, 10], nor by our study. Several investigators have dealt with the seasonal variation in the incidence and/or intensity of pregnancy loss and pregnancy complications such as pre-ecclamsia (PE) and placental abruption (PA) [9-12].

Being close to the huge deserts of the Sahara and Saudi Arabia, the south of Israel (the Negev desert) is meteorologically defined as a semi-arid area (large negative temperature gradient close to sunset and increased concentration of air-suspended particulates); its weather conditions are strongly dependent on the dominant direction of air streams: western or desert. It is felt especially in the spring and autumn seasons when routine daily rotation of wind is often disturbed, wind speed varies very quickly and specific desert winds arrive. The influence of winds on pregnant women has been mentioned [2, 4, 13, 14]. Our results confirmed the existence of two links: strong winds – preeclampsia and *Sharav,* blowing from surrounding deserts and characterized by specific barometric distribution, and sharp variations in meteorological state and transportation of big desert air volumes – placental abruption.

Materials and Methods

The meteorological equipment of the Electrical Engineering Department, BGU, contains a CR10 DATALOGGER and sensors to measure 17 parameters. Data sampled by the MATLAB computing environment are registered and averaged over half an hour, month and year.

The obstetrical data were obtained from the computerized file of Department of Obstetrics and Gynecology, Soroka Medical Center and Faculty of Health Sciences, BGU, between January 1 and December 31, 1999. The Soroka Medical Center in Beer-Sheva is the only tertiary care medical facility in the south of Israel that provides hospital care for a population of approximately 750,000.

Revised manuscript accepted for publication May 29, 2006

Preeclampsia was defined as pregnancy-induced increase in blood pressure over 140/90 and increased concentration of albumen in urine and/or edema occurring after 20 weeks of gestation. Placental abruption was defined as premature separation of the placenta before the birth of the fetus.

Statistical analysis

Multivariate analysis, time series approach and Poisson regression [15] were used; these techniques usually perform well in finding a degree of association between variables. In our study there were the number of all daily pregnancy pathologies N_{PE} and N_{AP}, as dependent variables, and meteorological factors, including temperature T^{o}_{m}, humidity *RH*, their daily overall differences ΔT^{o} and $\Delta(RH)$, *Sh*arav and strong winds *WW* as independent variables for the time period of one year. For all variables, whether dependent or independent, respective temporal distributions were studied. A value of $p < 0.1$ was considered significant.

Results

The current physical conditions in the atmosphere (weather) were described by maximum daily $T^{o}C$ and relative humidity *RH* %, duration of Sharav and strong winds in days *(Sharav(d))* and *(WW(d))* and daily overall differences of T^{o} and *RH:* $\Delta T^{o}=T^{o}_{m}- T^{o}_{min}$ and $\Delta(RH) = RH_{m} - RH_{min}$ (Table 1). The desert wind Sharav, passing over the South of Israel usually in spring and autumn months, is accompanied by the motion of big desert air volumes and specific distribution of atmospheric pressure; it may be very dry and hot. Sharav was registered 35 times. Strong winds (WW), generally blowing from the West and characterized by a speed ≥ 5 $m{\cdot}s^{-1}$, were obtained on 168 days.

Obstetrical data include total number of births N_{to} and incidences of PE and PA - N_{PE} and N_{PA} (Table 2). From 11,979 registered births, 94 were complicated with *PA* and 109 with *PE*. Monthly average for PE and PA (0.8% and 0.9%, respectively) fits the data from other countries. Seasonal and monthly variations in N_{PE} and N_{PA} were registered (all with $p < .05$). The relative incidence of PE and PA (50-60% up to their annual means) peaks in March-April, in November (PA) and in a late autumn (PE) - Figures 1 and 2. Generally, the most dangerous months belong to the unstable periods of the year: passages from winter to summer and *vice versa*, when the leap of T_m between two days can be up to 10°C, leap of RH_m and RH_{min} reaches up to 10% and 30%, correspondently, and air streams quickly change their direction.

Table 1. — *Daily averages of the main meteorological variables and their standard deviations (in parentheses) in Beer-Sheva in the year 1999.*

Variable	T_m°C	RH_m%	$\Delta T^{o}C$	$\Delta(RH)$%	*Sharav*(d)	*WW*(d)
January	18.3 (2.4)	82 (12.1)	10.7	34.7	0	4
February	22.6 (3.3)	87 (6.8)	12.3	44.9	0	8
March	18.9 (3.7)	82 (13.5)	11.5	44.3	4	7
April	25.3 (4.4)	84 (9.1)	13.0	45.1	4	14
May	31.2(9.6)	83 (11.4)	15.4	49.3	6	23
June	31.8(2.1)	84 (6)	12.4	45.8	4	17
July	31.4(1.4)	88 (2.6)	12.6	48	0	17
August	36.2(1.8)	88 (3.3)	14.1	48.5	3	17
September	33.2(2.4)	88 (4.9)	14.9	45.5	6	24
October	29.5 (1.9)	87.6 (2.9)	13.1	42.4	3	20
November	25.5 (4.2)	74 (16.6)	13.4	38.3	5	10
December	22.2 (2.7)	73 (17.5)	13.4	49.3	0	5
Annual average	27.5 (6.9)	83.4 (11.2)				

T_m°C: average maximum daily temperature; RH_m%: average maximum daily relative bumidity; ΔT(°C) = T_m - T_{min}: overall daily difference in temperature; $\Delta(RH)$ % = RH_m - RH_{min}: overall daily difference in humidity; *Sharav*(d): duration of Sharav in days; *WW*(d): duration of strong winds in days.

Table 2. — *Number of births, cases of preeclampsia and placental abruption in 1999.*

Month	*N*	N_{AP}	N_{AP}%	N_{PE}	N_{PE}%
January	1042	9	0.9	6	0.6
February	1008	4	0.4	4	0.4
March	980	9	0.9	16	1.6
April	867	10	1.2	9	1.0
May	852	7	0.8	5	0.6
June	902	5	0.6	8	0.9
July	1012	9	0.9	7	0.7
August	1084	4	0.4	8	0.7
September	1084	6	0.6	11	1.0
October	1030	9	0.9	11	1.1
November	1094	14	1.3	8	0.7
December	908	8	0.9	16	1.8
Annual total	11979	94		109	
Monthly average	998	8	0.8	9	0.9

N: number of births; N_{PE}: number of preeclampsia cases; N_{PE}%, = (N_{PE}/N) x100% relative part of preeclampsia cases; N_{PE}: number of placental abruption cases; N_{PA} % = (N_{PA}/N) x 100%, relative part of placental abruption cases.

Table 3. — *Sample of* partial *results of multivariate analysis for the correlation between some meteorological parameters and incidence of preeclampsia N_{PE} and placental abruption N_{API} (p values).*

	Variable	RH_m	T^{o}	ΔT^{o}	$\Delta(RH)$	*WW*	Sharav
NPA	Direct correlation	p = 0.000					
	Type of correlation	negative	positive			positive	
	Seasonal variation		p = 0.004				
	Monthly variations					p = 0.03	
NPE	Direct correlation			p = 0.027	p = 0.029		
	Type of correlation			positive	positive		
	Seasonal variations						
	Monthly variations			p = 0.02	p = 0.007		p = 0.000

N_{PA} was affected by maximum *RH* in an inverse correlation ($p = .000$), by *WW* (p = .03) and much weaker by *Sharav* (p = .098). Influence of T^{o}_{m} is expressed indirectly with seasonal periodicity ($p < .05$).

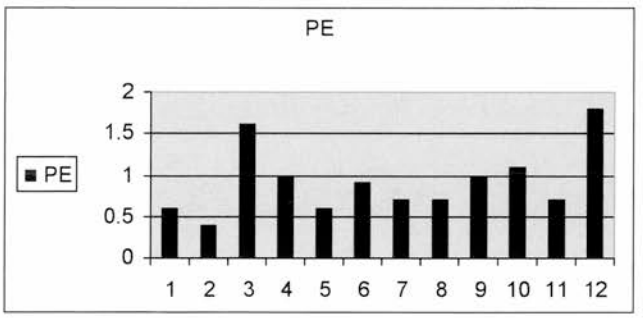
N_{PE} was affected by $\Delta(RH)$ ($p < .01$) and by a wide daily temperature range ΔT^{o} ($p = .027$); peak of this influence preceded sharp variations in temperature (ΔT^{o}) with an average of a 3-day lag ($p < .003$). The effect of *Sharav*, within a monthly period ($p < .01$), was also observed (Table 3).

Generally strong winds were associated with increased frequency of PA ($p < 0.002$), while desert wind of Sharav involved increased incidence of PE ($p < 0.033$).

Discussion

The connection of living systems with the environment, expressing in permanent exchange matter and energy, makes humans very sensitive to any violation in the external orderliness. Every breach of the habitual rhythm may disturb any part of an organism. For the well-being of weather-sensitive people, alterations in the activity of

Fig. 1



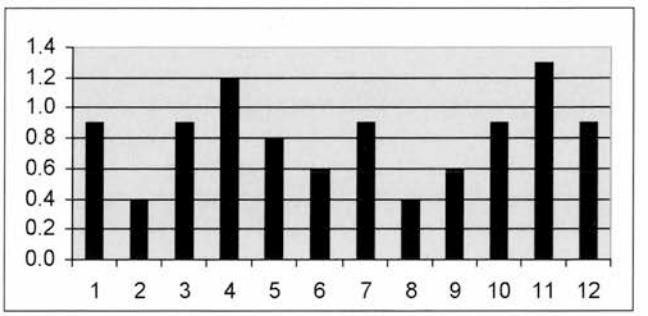


Fig. 2

Figure 1. — Monthly distribution of the relative incidence of preeclampsia (N_{PE}/N) x 100% in 1999.
Figure 2. — Monthly distribution of the relative incidence of placental abruption (N_{PA}/N) x 100% in 1999.

hormones sensitive to weather perturbations, are of decisive importance since they may be expressed in exacerbation of almost all chronic diseases, hyperkineses, acute sickness, polyuria, irritability, nervous tension, abdominal pain, tremor, exhaustion, serotonin hyperproduction, convulsions, latent hyperthyroidism, etc. [16-20]. Under stressful situations or sharp or unusual perturbations in the synoptic state, significant metabolic changes take place in 86% of humans [20]. Higher sensitivity of women to weather leaps can be explained by their more impressionable nervous system and has been mentioned since ancient times [4, 21, 22]; it might especially be felt by pregnant women whose hormonal systems are excited.

Strong or specific air streams are complicated stressors, involving multiform breaches in normal human life, especially in arid and semi-arid areas, because they are accompanied by the sometimes extreme changes (during a few hours) in T^v, *RH*, concentration of air-suspended particulates and other parameters. A characteristic feature of the air mass motion from the East and Red Sea is increased pressure in the higher air layer, preventing vertical transfer of the pollutants and forcing them to stay near the ground; that situation should be very detrimental for women with respiratory and heart problems.

The impact of ambient T^v and *RH* on birth complications should become smoother from year to year with housing conditions improving together with the prevalent indoor occupation of women. The majority of the Negev population lives in apartments built on the standards of modern technology and concepts with a relatively high level of comfort.

Preeclampsia - PE

One of the definitions of preeclampsia is "pregnancy-induced increase in blood pressure *(BP)* with proteinuria" but hypertension generally is the most common chronic disease observed and the number one cause for physician visits. We can not take into consideration factors that contribute to variability in *BP* as smoking, caffeine and alcohol intake. Nonetheless, it is obviously, very important for early detection of women susceptible to hypertension.

Usually the influence of T^v on *BP* is weak. However if several weather parameters, acting together, change too quickly, the "normal" comfort feelings of the person could be disturbed. Indeed, the rise in the percentage of NPE was observed in most unstable seasons when ΔT^v can reach more than 20°C and $\Delta(RH)$ over 60% (Table 1). The meteorological perturbations connected with the *Sharav* state can cause sharp variations in *BP*, hormonal changes, polyuria, asthma attacks, nervous tension, etc., stimulating *PE* [14, 23]. Obviously, the effect of *Sharav* on N_{PE} ($p < .002$) reflects mostly its influence on *BP*.

Placental abruption - PA

Cited in the literature the average number of *PA* is about 1:120 labors – it fits our data. One of the circumstantial reasons could be air streams: "Wind in the body resembles the wind in nature; wind affects the body just as it moves the branches and leaves of a tree" [22]. "Mechanical" atmospheric instability can give rise to the alteration of important physiological functions, asthma attacks, twisting, internal tremors and convulsions, paralysis or migrating pain. Any of these symptoms can stimulate the beginning of *PA*. Due to the relative rarity of *Sharav*, its influence on N_{PA} is noticeably less than that of *WW*. Hot air dries the mucus membranes and suspended particles can more easily penetrate inside and cause irritation, allergic reactions, asthma, exhaustion, etc., therefore correlations of N_{PA} – indirectly with T^v and inversely with *RH* with different periodicities – were expected.

Conclusions

This research is the collective work of specialists who are attempting to bridge the points of view from different areas of science (physics, atmospheric electricity, medicine) on the specific problems of labor disorders. This first report could lay the foundation for further investigations on the influence of total atmospheric state on expectant mothers. The results of this study support the hypothesis that the meteorological environment affects frequency of *PA* and *PE* occurrence. Obviously, the dominant influential factor is the ensemble of variables, specific for each disorder and for each region. In semi-arid

areas a decisive role is played by specific air streams. The logical connection between reactions of the female organism to the perturbations in the atmospheric state was manifested in the fact that different symptoms occur as a reaction to different parameters: mechanical atmospheric instability, originating from strong winds, can give rise to asthma attacks and muscular contractions – any of these symptoms *can stimulate the beginning of PA*, while sharp and fast weather violations, accompanying Sharav, influence mostly internal physiological processes, *provoking PE.*

The study can help to predict the kinds of pathologies in according with weather. Obstetricians working in semi-arid areas like the Negev desert should be aware of the influence of unstable weather conditions on the incidence of PE and PA, especially in the spring and autumn seasons. Preventive precautions and universal compulsory 'keeping an eye on' expectant mothers could improve their health and decrease the number of labor disorders.

Acknowledgement

The authors wish to thank Prof. E. Paran for consultations about hypertension problems, and Ms. G. Ferman and Dr. H. Vardi for their help in the accumulation of experimental data.

References

[1] Capra F.: "A new synthesis". In: The web of life. N.Y., Anchor Books Doubleday, 1996, 157.
[2] Sulman F.-G.: "Short-term changes of weather and climate". In: "Short- and long-term changes in climate". Roca Raton, FL, CRC Press, Inc. 1982, 10.
[3] Driscoll D.M.: "Weather and childbirth: a further search for relationships". *Int. J. Biometeor.,* 1995, *38,* 152.
[4] Hippocrates. On Endemic Diseases: Airs, Waters and Places, Mattock JN, Lyons MC (eds.). Cambridge, Heffer and Sons, 1969.
[5] Lajinian S., Hudson S., Appelwhite L.: "An association between the heat-humidity index and preterm labor and delivery: a preliminary analysis". *Am. J. Public Health,* 1997, *87,* 1205.
[6] Bider D., Sivan E., Seidman D.S.: "Meteorological factors in hypertensive disorders, vaginal bleeding and premature rapture of membranes during pregnancy". *Gynecol. Obstet. Invest.,* 1991, *32,* 88.
[7] Randall W.: "Photoperiod, temperature and regional patterns of conceptions in the USA". *Int. J. of Biometeor.,* 1993, *37,* 52.
[8] Halpern G.J., Stoupel E.G., Barkai G. *et al.*: "Solar activity cycle and the incidence of foetal chromosome abnormalities detected at prenatal diagnosis". *Int. J. Biometeor.,* 1995, *39,* 59.
[9] Jamelle R.N.: "Eclampsia: is there a seasonal variation in incidence?". *J. Obstet. Gynecol. Res.,* 1998, *24,* 121.
[10] Makhseed M., Musini V.M., Ahmed M.A., Monem R.A.: "Influence of seasonal variation on pregnancy induced hypertension and/or preeclampsia". *Aust. N Z J Obstet. Gynecol.*, 1999, *39*, 196.
[11] Nonaka K., Imaizumi Y.: "Deaths from cerebrovascular diseases correlated to month of birth: elevated risk of death from subarachnoid hemorrhage among summer-born". *Int. J. Biometeor.*, 2000, *44*, 182.
[12] Bergström S., Povey G., Songane F., Ching C.: "Seasonal incidence of eclampsia and its relationship to meteorological data in Mozambique". J. Perinat. Med., 1992, *20,* 153.
[13] Verhoef M.J., Rose M.S., Ramcharan S.: "The relationship between chinook conditions and women's physical and mental well-being". *Int. J. Biometeor.*, 1995, *38*, 148.
[14] Rose M.S., Verhoef M.J., Ramcharan S.: "The relationship between chinook conditions and women's illness-related behaviors". *Int. J. Biometeor.*, 1995, *38,* 156.
[15] Goldsmith J.R., Friger M.D., Abramson M.: "Associations between health and air pollution in time-series analyses". *Archives Envir. Health*, 1996, *51*, 359.
[16] Fuxe K., Agnati L.F., von Euler G., Lundgren K., Zoli M., Bjelke B., Ogren S.O.: "Galanin/5-HT receptor interaction. A new integrative mechanism in the control of neurotransmission in central nervous system". In: Paoletti R., Vanaoutée P.M., Brunello N., Maggi F.M. (eds.). "Serotonin from cell biology to pharmacology and therepeutics". Boston, Kluwer Acad. Pub., 1990.
[17] Bergiannaki J.D., Paparrigopoulos T.J., Stefanis S.N.: "Seasonal pattern of melatonin excretion in humans: relationship to daylength variation rate and geomagnetic field fluctuations". *Experientia,* 1996, *52,* 253.
[18] Tromp S.W.: "Physiological effects". In: "Biometeorology. The impact of the weather and climate on humans and their environment (Animals and plants)". London, Heyden & Sons Ltd, 1980, 110.
[19] Vondrasova D., Hajek I., Illnerova H.: "Exposure to long summer days affects the human melatonin and cortisol rhythms". *Brain Res.* 1997, *759,* 166.
[20] Sulman F.-G.: "The impact of weather on human health". *Rev. Envir. Health.,* 1984, *4,* 83.
[21] Aikman H.: "The association between arthritis and weather". *Int. J. Biometeor.*, 1997, *40,* 192.
[22] Macioca G.: "The causes of disease" *and* "Identifications of patterns according to pathogenic factors". The Foundation of Chinese Medicine: A Comprehensive Text for Acupuncturists and Herbalists. London, Churchill Livingston, 1995, 132, 293.
[23] Corbett S.W.: "Asthma exacerbations during Santa Ana winds in Southern California". *Wilderness Envir. Med.*, 1996, *7,* 301.

Address reprint requests to:
N.S. YACKERSON, Ph.D.
Department of Electrical
and Computer Engineering
Faculty of Technology
Ben-Gurion University of the Negev
P.O. Box 653
Beer-Sheva 84105 (Israel)