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METEOROLOGICAL RELATIONS OF ECLAMPSIA IN LAGOS, NIGERIA

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Summary

A retrospective study of the meteorological relations of eclampsia in Lagos, Nigeria supports other observations that the incidence of this disease varies significantly with the weather. Protective action by arid conditions is consistent with the known effect of dehydration on convulsions of differing aetiologies and is attributable to increased pulmonary transpirational water loss. Exacerbation of eclampsia by cool, humid conditions may therefore reflect excessive water retention, due partly to suppressed pulmonary transpiration and partly to kidney malfunction in those women.

In Cali, Columbia, the incidence of eclampsia varies according to weather conditions; it is inversely proportional to environmental temperature and directly proportional to relative humidity (Neutra, 1974). As Neutra pointed out, these findings merit further study, because they suggest the existence of hitherto unrecognized factors in the aetiology of this disease. We have studied the relation between the eclampsia rate and weather variables in Lagos, Nigeria. Our study also refers to tropical conditions, but Lagos is situated on the coast at sea-level, whereas Cali is located inland, at an altitude of 1000 m above sea-level.

The incidence of eclampsia in Lagos, as elsewhere, is about five times higher in primigravidae than multigravidae, but multigravidae are not materially different as regards the biochemical course and severity of the disease (Agobe, 1979). Moreover, since Neutra (1974) reported that seasonal variation in first pregnancies and differences due to parity, age and marital status had no discernible effect on the meteorological relations of eclampsia, those factors were not considered here. Nor was it possible to consider other possible factors such as seasonal nutritional variations, or the influence of seasonal differences in physical activity.

Subjects and Methods

Monthly total deliveries and monthly totals of women diagnosed as having eclampsia were taken from the obstetric records of Lagos University Teaching Hospital and the nearby Lagos Island Maternity Hospital for the years 1972–75 inclusive. These were pooled and the eclampsia rate was calculated for each month during the observation period. In that time 80 129 women were delivered and 821 had eclampsia. The corresponding mean monthly values of environmental temperature, barometric pressure, relative humidity and rainfall were obtained from the meteorological records

TABLE I

Mean (±SEM) monthly values of the eclampsia rate, environmental temperature, atmospheric pressure, relative humidity and rainfall for the years 1972–75 inclusive

Month	Eclampsia rate (per thousand hospital deliveries)	Environmental temperature (°C)	Atmospheric pressure (mb)	Relative humidity (%)	Rainfall (cm)
January	$3{\cdot}8 \pm 1{\cdot}1$	$24{\cdot}5 \pm 0{\cdot}3$	$1005{\cdot}9 \pm 0{\cdot}4$	$69{\cdot}5 \pm 1{\cdot}2$	$0{\cdot}9 \pm 0{\cdot}7$
February	$8{\cdot}3 \pm 0{\cdot}4$	$25{\cdot}6 \pm 0{\cdot}1$	$1005{\cdot}2 \pm 0{\cdot}3$	$69{\cdot}0 \pm 1{\cdot}4$	$7{\cdot}1 \pm 2{\cdot}3$
March	$8{\cdot}4 \pm 1{\cdot}1$	$25{\cdot}9 \pm 0{\cdot}2$	$1005{\cdot}1 \pm 0{\cdot}3$	$68{\cdot}1 \pm 0{\cdot}8$	$6{\cdot}3 \pm 1{\cdot}8$
April	$10{\cdot}6 \pm 1{\cdot}5$	$24{\cdot}9 \pm 0{\cdot}6$	$1005{\cdot}3 \pm 0{\cdot}2$	$71{\cdot}0 \pm 1{\cdot}0$	$11{\cdot}3 \pm 2{\cdot}8$
May	$11{\cdot}4 \pm 0{\cdot}9$	$24{\cdot}6 \pm 0{\cdot}3$	$1006{\cdot}3 \pm 0{\cdot}2$	$74{\cdot}6 \pm 1{\cdot}2$	$18{\cdot}6 \pm 1{\cdot}6$
June	$15{\cdot}0 \pm 1{\cdot}3$	$23{\cdot}5 \pm 0{\cdot}3$	$1007{\cdot}6 \pm 0{\cdot}2$	$78{\cdot}3 \pm 0{\cdot}8$	$24{\cdot}7 \pm 6{\cdot}4$
July	$13{\cdot}7 \pm 1{\cdot}3$	$22{\cdot}9 \pm 0{\cdot}4$	$1008{\cdot}3 \pm 0{\cdot}2$	$77{\cdot}6 \pm 1{\cdot}7$	$18{\cdot}2 \pm 7{\cdot}8$
August	$16{\cdot}6 \pm 1{\cdot}8$	$22{\cdot}2 \pm 0{\cdot}6$	$1008{\cdot}5 \pm 0{\cdot}2$	$76{\cdot}0 \pm 0{\cdot}4$	$8{\cdot}4 \pm 3{\cdot}0$
September	$11{\cdot}0 \pm 2{\cdot}8$	$22{\cdot}7 \pm 0{\cdot}1$	$1008{\cdot}2 \pm 0{\cdot}1$	$78{\cdot}1 \pm 1{\cdot}5$	$11{\cdot}0 \pm 4{\cdot}5$
October	$7{\cdot}5 \pm 2{\cdot}1$	$23{\cdot}8 \pm 0{\cdot}2$	$1007{\cdot}0 \pm 0{\cdot}2$	$76{\cdot}7 \pm 0{\cdot}7$	$11{\cdot}6 \pm 2{\cdot}7$
November	$7{\cdot}0 \pm 0{\cdot}8$	$24{\cdot}9 \pm 0{\cdot}3$	$1006{\cdot}5 \pm 0{\cdot}1$	$71{\cdot}8 \pm 1{\cdot}6$	$2{\cdot}4 \pm 1{\cdot}5$
December	$9{\cdot}4 \pm 1{\cdot}3$	$24{\cdot}8 \pm 0{\cdot}4$	$1006{\cdot}1 \pm 0{\cdot}2$	$70{\cdot}0 \pm 2{\cdot}0$	$2{\cdot}2 \pm 1{\cdot}3$

of local weather stations. These data were subjected to multivariate analysis.

RESULTS

The variation in the mean monthly values of the eclampsia rate, environmental temperature (T), atmospheric pressure (P), relative humidity (H) and rainfall (R) for the years 1972–75 inclusive are recorded in Table I. The eclampsia rate increased continuously from January to June, remained fairly steady through June to August and fell during September, while from October to December the rate was virtually constant. None of the weather variables exhibited a similar pattern of change, but the eclampsia rate tended to be highest when atmospheric pressure, relative humidity and rainfall were high and the environmental temperature was low, and conversely. There was, therefore, a seasonal association; the mean ± SEM eclampsia rate was $13{\cdot}3 \pm 0{\cdot}8$ during the main wet season, from May to July, but $6{\cdot}7 \pm 0{\cdot}9$ in the dry season, from November to January.

The zero-order correlation coefficients, using the 48 monthly values for each variable, are given in Table II, where all ten correlations exhibit statistically significant collinearity. According to these findings the eclampsia rate is inversely proportional to environmental temperature and directly proportional to atmospheric pressure, relative humidity and rainfall. Among the weather variables themselves environ-

TABLE II

Zero-order correlations of the variables for the 48 months of the observation period

	Eclampsia rate (per thousand hospital deliveries)	Environmental temperature	Atmospheric pressure	Relative humidity
Environmental temperature (°C)	$-0{\cdot}5192$ $p < 0{\cdot}001$			
Atmospheric pressure (mb)	$0{\cdot}4914$ $p < 0{\cdot}001$	$-0{\cdot}7865$ $p < 0{\cdot}001$		
Relative humidity (%)	$0{\cdot}4294$ $p = 0{\cdot}001$	$-0{\cdot}7390$ $p < 0{\cdot}001$	$0{\cdot}7411$ $p < 0{\cdot}001$	
Rainfall (cm)	$0{\cdot}4453$ $p = 0{\cdot}001$	$-0{\cdot}3795$ $p = 0{\cdot}004$	$0{\cdot}3083$ $p = 0{\cdot}017$	$0{\cdot}6006$ $p < 0{\cdot}001$

mental temperature correlates negatively with atmospheric pressure, relative humidity and rainfall. Atmospheric pressure correlates positively with relative humidity and rainfall, and the correlation of relative humidity with rainfall is also positive.

Of the first-order partial correlations between the eclampsia rate (E) and each variable in turn (T, P, H, R), controlling for the effect of one of the other three, the correlations with temperature are all weaker, but still negative and statistically significant (rET.P $= -0\cdot2466$; $p = 0\cdot047$: rET.H $= -0\cdot3317$; $p = 0\cdot011$: rET.R $= -0\cdot4227$; $p = 0\cdot002$). With eclampsia rate and atmospheric pressure, the partial correlation is not significant at constant temperature but, at constant humidity or rainfall, both correlations are positive and statistically significant (rEP.H $= 0\cdot2856$; $p = 0\cdot026$: rEP.R $= 0\cdot4158$; $p = 0\cdot002$). None of the first order partial correlations of eclampsia rate and relative humidity attain statistical significance, while all three for eclampsia rate with rainfall are significant (rER.T $= 0\cdot3140$; $p = 0\cdot016$: rER.P $= 0\cdot3546$; $p = 0\cdot007$: rER.H $= 0\cdot2595$; $p = 0\cdot039$).

Among the second-order partial correlations of the eclampsia rate and each variable in turn, controlling for the effect of two of the other three, only rET.HR is significant ($r = -0\cdot3783$; $p = 0\cdot005$) while the others are not, and with pressure only rEP.HR is significant ($r = 0\cdot3766$; $p = 0\cdot005$). Here again, correlations with humidity are not significant, but those with rainfall are all significant (rER.TP $= 0\cdot3152$; $p = 0\cdot016$: rER.TH $= 0\cdot3193$; $p = 0\cdot015$: rER.HP $= 0\cdot3585$; $p = 0\cdot007$).

In the third-order partial correlations of eclampsia rate and each variable in turn, controlling for the effect of all three others, the correlation with rainfall is highly significant (rER.THP $= 0\cdot3636$; $p = 0\cdot007$) while that with humidity is not, observations which are consistently the same irrespective of the number of variables controlled. The correlations of eclampsia rate with either temperature or pressure are, however, both substantially weaker (rET.HRP $= -0\cdot2311$; $p = 0\cdot063$: rEP.HRT $= 0\cdot2281$; $p = 0\cdot066$) and below the five per cent significance level.

According to these results, therefore, the eclampsia rate in Lagos is highly dependent on rainfall, but not at all on relative humidity, while its relation with environmental temperature and atmospheric pressure is negligible.

The interactions of the weather variables themselves are relevant to this problem and their second-order partial correlations are informative. At constant humidity and rainfall, atmospheric pressure falls as environmental temperature increases (rTP.HR $= -0\cdot5182$; $p < 0\cdot001$), because the density of air decreases as the temperature rises. Humidity decreases with rising temperature at constant pressure and rainfall (rTH.RP $= -0\cdot3044$; $p = 0\cdot020$) because the density of water vapour also falls. With increasing humidity at constant temperature and rainfall (rHP.TR $= 0\cdot4377$; $p = 0\cdot001$), however, the partial pressure of water vapour increases and atmospheric pressure rises, and humidity depends on rainfall (rHR.TP $= 0\cdot5442$; $p < 0\cdot001$) at constant temperature and pressure. Neither the partial correlation of temperature with rainfall at constant pressure and humidity nor that of pressure with rainfall at constant temperature and humidity are statistically significant. Of the four significant partial correlations, therefore, three are concerned with atmospheric water content, for water vapour is the most variable of the atmospheric constituents.

Discussion

By employing mean monthly values of the relevant variables in the present work, sensitivity is reduced and some relations are weakened, while others are strengthened. The results reported here are therefore different from those of Neutra (1974) but they are complementary rather than contradictory. A seasonal variation in the eclampsia rate is, for example, quite clear in this study, but there is apparently no connection between the incidence of eclampsia and relative humidity, yet there is a strong and consistent correlation with rainfall. With regard to relative humidity, the present observations are almost certainly due to reduced sensitivity, for the range in Lagos lacks the above-average, nearer saturation values, which double the eclampsia rate in Cali (Neutra, 1974); this probably explains the absence of any significant correlations. Rainfall, on the other hand, is virtually the same in both studies, around 120 cm annually; but rainfall is also an index of persisting saturation which, in this instance, is a better predictive factor than relative humidity and is strongly and positively correlated with the eclampsia rate. The significant negative correlations of eclampsia rate with environmental temperature are in agreement with Neutra's observations, but the loss of statistical significance by the third-order partial correlation indicates that the direct effect of temperature itself is negligible. A similar situation prevails with the correlations of eclampsia rate and atmospheric pressure, which are generally positive and have not previously been reported. Here, too, the third-order partial correlation is not significant, so the direct effect of pressure is also negligible. The elimination of environmental temperature and atmospheric pressure as factors with a direct influence on the eclampsia rate is, of course, quite in keeping with the effectiveness of thermal homeostasis and respiratory adaptation. Neutra (1974) found it impossible to assess the effect of temperature and humidity separately, although the incidence of eclampsia varied significantly with the absolute values of both variables at the time of the convulsive episode. The present work suggests, however, that environmental temperature—and atmospheric pressure—are relevant only in so far as they affect the state of water vapour in the atmosphere. Thus, while the average temperature in Lagos is much the same as in Cali, and hot, dry weather clearly alleviates the condition in both places, the lower water-vapour pressure due to the altitude of Cali is associated with an eclampsia rate only about half that in Lagos.

Both altitude and arid conditions favour dehydration and in the present context it is noteworthy that, despite their differing aetiologies, epileptic (McQuarrie, 1929; Reynolds, 1970) and hypoglycaemic convulsions (Drabkin and Ravdin, 1937) are also alleviated by dehydration. In discussing his findings Neutra (1974) discounted dehydration due to sweating as a significant factor in the apparent protective action of raised environmental temperature. This is understandable, because sweating is subject to hypothalamic control and its primary function is the regulation of body-heat loss. Sweating, however, is not the only source of transpirational body-water loss, for transpiration also occurs via the lungs, where it is not subject to physiological control. In the lungs, some 50 m^2 of surface area is exposed to inspired air, which is separated from blood only by a thin membrane that specifically effects rapid gas and vapour transfer according to concentration gradients. It is not unlikely, therefore, that when inspired air is hot and dry, pulmonary transpiration is considerably enhanced, but when that air is cool and wet, water loss by this route is appreciably suppressed. Bearing in mind that kidney malfunction is common in pre-eclampsia/eclampsia, the hydration state of those women could well be more vulnerable to environmental influence than it is in normal subjects.

More direct evidence of the connection between the state of body water and eclampsia was obtained by comparing maternal serum osmolarity and susceptibility to convulsions in selected subjects. These were women who had been included in a comprehensive biochemical study (Agobe, 1979) of pre-eclampsia/eclampsia carried out during the wet-season months of

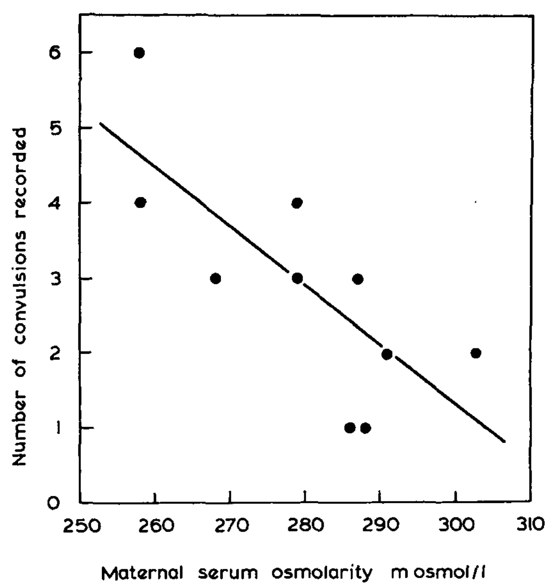

FIG. 1

Correlation of the number of convulsions recorded and maternal serum osmolarity in untreated subjects who became eclamptic before the onset of labour.

DF = 8; $r = -0{\cdot}7569$; $p < 0{\cdot}05$.

May and June 1977. For the present purpose, however, the subjects were restricted to those who became eclamptic before the onset of labour, from whom blood samples had been taken before any form of treatment was initiated and for whom the number of convulsions had been recorded. The results are shown in Figure 1, where there is a statistically significant negative correlation between the incidence of fits and maternal serum osmolarity. According to this finding, therefore, susceptibility to convulsions increases with increasing water retention. Thus, while the induction of diuresis has no influence on the development of pre-eclampsia (Campbell and MacGillivray, 1975), it may nevertheless be beneficial in retarding the onset of eclampsia.

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