

Impact of Climate Change on Epilepsy Patients with Age Stratifications: Variability of Temperature and Relative Humidity Effects

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ABSTRACT

The paper examined the impact of climate change on epilepsy patients (in- and out- patient) that visited Neuropsychiatric Hospital Akure, Ondo State, Nigeria. The main independent variables of interest are temperature and relative humidity as climate the two parameters covering a period of eight years 2010-2017. Data of in and out patients diagnosed with epilepsy and other related cases were sourced from the hospital records. The population of the study is 2873 epilepsy patients that visited the hospital within the period of study, comprising of 143 (4.98%) age 0-4 years, 447 (15.56%) age 5-9 years, 963 (33.52%) age 10-19 years, 983 (34.22%) age 20-44 years, 273 (9.50%) age 45-64 years, 36 (1.25%) age 65-69 years and 28 (0.97%) age 70+ years. And for the purpose of analysis and discussion the population of study was further stratified into; Children aged (0-19 years) 1553 (54.05%), adult aged (20-64 years) 1256 (43.72%), older adult aged (65-69 years) 36 (1.25%) and elderly aged (70 +) 28 (0.97%). Data collected were analyzed with the use of single regression Analysis. The study found climate parameters (temperature and relative humidity) make population vulnerable to the risk of epilepsy cases and therefore increases their visits to the hospital. There are positive associations between the number of epilepsy patients in the Neuropsychiatric Akure and the increase in the two climate two parameters (i.e. temperature and relative humidity). Children aged population are more vulnerable to the risk of epilepsy mental ill-health as temperature increases while adult aged population are more vulnerable to the risk of epilepsy mental ill-health as relative humidity increases. Among children aged, the age group 10-19 years emerged to be more vulnerable to the risk of epilepsy with increase in temperature while age group 20-44 years among the adult aged emerged to more vulnerable to the risk of epilepsy as relative humidity increases. Generally, Epilepsy developed more in those adults than the children when sum the contributions from the two parameters. The vulnerability of various age groups population to epilepsy cases was not equally distributed throughout the year 2010-2017 and this is an indication that different age groups responded differently to the effects of temperature and relative humidity variability.. The effective strength of relative humidity is on the children and adult aged than others group (i.e. older adults and elderly), but more on the adult aged while the effective strength of temperature is seen more on the children aged than others group (i.e. Adults, older adults and elderly)

How to cite this paper: Jaiyeola O. Paul | Abdullahi Ayegba | Esu S. Ulaetor "Impact of Climate Change on Epilepsy Patients with Age Stratifications: Variability of Temperature and Relative Humidity Effects" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-2, February 2020, pp.786-791, URL: www.ijtsrd.com/papers/ijtsrd30153.pdf



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Keywords: Temperature, Relative Humidity, Patients and Epilepsy cases

1. INTRODUCTION:

Epilepsy (Severe Seizure) is any of various neurological disorders characterized by sudden, recurring attacks of motor, sensory, or psychic malfunction with or without loss of consciousness or convulsive seizures. Also referred to as abnormal electrical conduction in the brain resulting into involuntary muscle movement, sensory disturbances and altered consciousness

Febrile seizure also known as convulsion, body spasm or shaking occur mainly in children and are caused by fever; As with most type of seizures the onset is dramatic, with little or no warning. In most instances the seizure lasts for only a few minutes and stops on its own. Febrile seizures may occur because a child's developing brain is sensitive to the effects of fever (Fukuda M, 1997). These seizures

are mostly likely to occur with high body temperature (higher than $102^{\circ}F$) but also occur with milder fevers. The sudden rise in temperature seems to be more important than the degree of temperature. The seizure may occur with the initial onset of fever before a child’s caregiver is even aware the child is ill (Kelvin K). Development of Epilepsy with fever can occur when the temperature is high enough. Febrile seizure can be seen when a child has a high fever, most commonly above $38.3^{\circ}C$ ($101^{\circ}F$) and usually the first day of a rapid rise in body temperature. Complex febrile seizure may be more threatening and can occur at body temperatures lower than $38.3^{\circ}C$ and last longer than 15 minutes (Epilepsy Onitario, 2018). Margriet et al (1998) in their research concluded that half of the recurrent seizures occur in the first 2 hours after onset of fever a subsequent episode. If seizure reoccurs at a later time, the temperature at seizure is higher compared with recurrences occurring in the first 2 hours of fever. Young age at fever onset, higher temperature at fever onset, and high temperature during the episode of fever are associated with an increased risk of a recurrent febrile seizure. Furthermore, the risk of a recurrence of febrile seizure, at a moment that a child with a history of febrile seizure has fever again, decreases with age and increases with temperature at fever onset and temperature during fever.

The contribution of environment, namely the increase in brain temperature (hyperthermia) to Epilepsy generation, has become evident from the use of animals, where hyperthermia leads to seizure in practically all rats or mice. Elevating brain temperature in itself alters many neuronal functions, including several temperature-sensitive ion channels. This should influence neuronal firing and probability of generating massive synchronized neuronal activity, i.e. Epilepsy (seizure). Remarkably, hyperthermia provoked by medication overdose or hot baths often provoke Epilepsy in young children, indicating that increase in brain temperature may suffice to generate epilepsy. Fever also can cause increase in temperature, so fever and hyperthermia share epilepsy’s common mechanisms to provoke (Celine et al. 2009). Some studies have not found positive correlation between epilepsy and temperature. Florian et al (2017) in their research found that High ambient temperatures of $> 20^{\circ}C$ decrease seizure risk by 46% in the overall study population in subgroups, with the greatest effects observed in male patients and they were surprised about their result because their expectation was that seizure should increase with increase in temperature. Referring to some studies

they wrote: We found that high temperature of $> 20^{\circ}C$ seem to be a protective factor for epilepsy seizures, whereas low temperature did not affect seizure risk. Ascertainment of this nonlinear relationship between temperature and seizure risk explains why our first analysis – which assumes linearity- did not produce significant results. This finding that warmer temperatures offer a protective factor for epilepsy seizures was a somewhat unexpected finding, and the reason for this remains unclear. Considering high frequency of febrile seizure in children who are triggered by hyperthermia-induced respiratory alkalosis and the successive increase in neuronal activity, we anticipated that if temperature is associated with epilepsy seizure risk the particularly warm or hot weather would be a major risk factor. A higher body temperature also increases hippocampal-hippocampus (central role in the formation of memories) neuronal activity involved in mesial temporal lobe epilepsy.

2. Methodology

Data were drawn from two sources of secondary data: (i). Neuropsychiatric Hospital Akure, Ondo State where the monthly and yearly number of in- patients and out-patients that visited the Hospital with epilepsy from the year 2010 to 2017 were collected (ii). The meteorological data on temperature and relative humidity on Ondo state from 2010-2017 were retrieved from the Modern-Era retrospective analysis for Research Application, Version 2 (MERRA-2) web site and used for the study. Mean value instead of minimum and maximum value of temperature and relative humidity were used. The ex-post facto research design was adopted for the study and data collected were analyzed with use of STATA; single regression analysis. Total number of in-patients and out-patients visiting the hospital with epilepsy cases for eight years (2010-2017) was 2873 comprising a total number of age 0-4 years patients to be 143 (4.98%), age 5-9 years were 447 (15.56%), age 10-19 years were 963 (33.52%), age 20-44 years were 983 (34.22%), age 45-64 years 273 (9.50%), age 65-69 years 36 (1.25%) and age 70+ years were 28 (0.97%). Further stratified to Children aged 0-19 years were 1553 (54.05%), adults aged 20-64 were 1256 (43.72%), older adult aged 65-69 were 36 (1.25%) and elderly aged 70+ years were 28 (0.97%). Internet facility was employed for this research especially e-library to retrieve text books, journals, research papers etc. for an update information on the topic from other researchers and related studies e.g. Google Alerts and Google Trends to rack comprehensive search over a lengthy period.

3. Data Presentation and Data Analysis

3.1. Data Presentation

Table1: Stratifications: Epilepsy Age Distributions (2010-2017)

	Age 0-4 Yrs.	Age 5-9 Yrs.	Age 10-19 Yrs.	Age 20-44 Yrs.	Age 45-64 Yrs.	Age 65-69 Yrs.	Age 70 And Above	Total	Temperature (T) (°C)	Relative Humidity (RH) (%)
Jan	19	33	59	66	15	2	3	197	24.5	76.75
Feb	18	27	59	53	20	0	0	177	25.88	82.87
Mar	14	22	90	77	13	0	0	216	26.25	86.3
Apr	8	36	100	77	6	0	0	227	26.13	88.13
May	9	32	85	76	46	1	0	249	25.71	89.8
June	16	46	112	126	21	0	0	321	24.96	90.02
July	3	33	72	59	11	2	0	180	24.32	89.36

August	12	40	76	60	32	0	0	220	24.11	88.7
Sept	7	50	51	144	41	17	6	316	24.5	89.53
Oct	23	24	93	88	17	0	1	246	25.13	89.24
Nov	9	51	78	90	30	13	17	288	25.53	86.45
Dec	5	53	88	67	21	1	1	236	24.39	77.38
Total	143	447	963	983	273	36	28	2873		

3.2. Data Analysis

3.2.1. Single (Linear) Regression Analysis

Table2: Epilepsy

STATA Parameters	Age 0-4		Age 5-9		Age 10-19		Age 20-44		Age 45-64		Age 65-69		Age 70 +	
	T	RH	T	RH	T	RH	T	RH	T	RH	T	RH	T	RH
Coefficient	1.618	-0.162	-6.494	-0.233	7.571	1.157	-2.655	2.501	-2.87	0.705	-1.27	0.17	0.116	-0.042
t	0.65	-0.4	-1.66	-0.31	1.07	1.01	-0.23	1.51	-0.58	0.9	-0.54	0.45	0.06	-0.21
P	0.532	0.7	0.131	0.76	0.312	0.338	0.82	0.162	0.577	0.592	0.599	0.604	0.956	0.903
R ² (Overlapping)	0.0402	0.0155	0.2131	0.0097	0.1019	0.1019	0.0054	0.1854	0.0321	0.0742	0.0286	0.0196	0.0003	0.0016
% of Determination	4.02%	1.55%	21.31%	0.97%	10.19%	9.19%	0.54%	18.54%	3.21%	7.42%	2.86%	1.96%	0.03%	0.00%
Number of Patients	143	143	447	447	963	963	983	983	273	273	36	36	28	28
Number of Patients Attributed to the Parameters	6	(-)2	(-)95	(-)4	98	88	(-)5	182	(-)9	20	(-)1	1	0	0

Age groups 0-4 and 10-19 years have 6 and 98 numbers of patients respectively traceable or attributed to increase in temperature. The remaining five age groups cannot be traceable to increase in temperature because of negative association between the number of epilepsy patients in those groups and increased in temperature.

The age groups 10-19, 20-44, 45-64 and 65-69 years have 88, 182, 20 and 1 numbers of patients with epilepsy mental ill-health respectively traceable or attributed to increase in the relative humidity. But age 10-19 years has number of patients 98 and 88 respectively traceable to the increase in temperature and relative humidity while none of the number of epilepsy patients for age 70+ were traceable to any of the two parameters.

4. Findings

The age distributions will be further brokendown into age groups comprising of children, adults, older adults and elderly aged for purpose of discussions, because the contributions of both parameters can be computed under children, adults, older adults and the elderly aged.

- The children are grouped below age 19 (*or* ≤ 19) years i.e. (0-4, 5-9, 10-19) years
- Adults age were grouped within age 20-64 (*or* $20 \geq x \leq 64$) i.e. (20-44, 45-64) years: the groups are among the working class in Nigeria civil service especially in Universities and Research institutes.
- Older adults were grouped within age 65-69 (*or* $65 \geq x \leq 69$) years, Retired age in the Nigeria civil services most especially in the Universities and the research institutes
- Elderly were grouped for age equal or greater 70 (*or* ≥ 70) years: out of civil services but surface in the political activities even from president downward.

Table3: Contribution and % Contribution from Temperature and Relative Humidity

Age Group	Temperature		Relative Humidity	
	Temperature Contribution	% Attributed to Temperature	Relative Humidity Contribution	% Attributed to Relative Humidity
Age 0-4	6	6%	0	0%
Age 5-9	0	0%	0	0%
Age 10-19	98	94%	88	30%
Age 20-44	0	0%	182	63%
Age 45-64	0	0%	20	7%
Age 65-69	0	0%	1	0%
Age 70+	0	0%	0	0%
Total	104	100%	291	100%

From table 3 above

- The total number of epilepsy patients traceable to the increase in temperature extracted from all the age groups was 104 in number. Here we have contributions mainly as follows: 0-4 years 6(6%) and 10-19 years 98(94%), these are mainly children i.e. 5-9 and 10-19 years and having children group to be (100% of 104). The children aged

populations are more vulnerable to risk of epilepsy cases as temperature increases more than other groups, while within the children's ages, the age group 10-19 emerged to be more vulnerable.

- The total number of epilepsy's patients traceable to the increase in the relative humidity extracted from all the age groups was 291 in number. Here we have contributions mainly as follows: 10-19 years 88(30%), 20-44 years 182(63%) and 45-64 years 20(7%) those age groups are within the children group and adults aged i.e. 0-19 years being the children group were 30% and 20-64 years being the adults' group were 70%. Children and adults aged are more vulnerable at higher risks of epilepsy mental ill-health than other groups as relative humidity increases. Age group 20-44 emerged to be more vulnerable with increase in relative humidity. But the older adults (65-69 yrs.) and elderly aged (70+) are with no obvious epilepsy mental ill-health with increase in relative humidity.

In summary, the children populations are more vulnerable to risk of epilepsy cases as temperature increases more than other groups, while within the children age, the group age 10-19 emerged to be more vulnerable as temperature increases while Children and adult aged are more vulnerable at higher risks of epilepsy mental ill-health than other groups as relative humidity increases. Age group 20-44 emerged to be more vulnerable with increase in relative humidity.

The Degree at which increase in Temperature and Relative Humidity Spreads Epilepsy Mental ill-Health among Age Groups

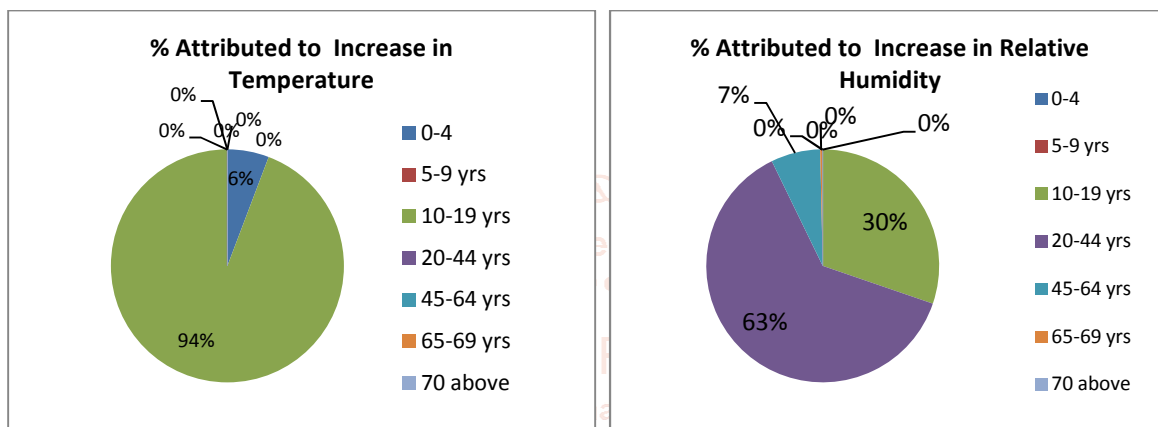


Table4: Number of Patients Attributed to the Two Parameters and their % Contribution

Age Group	Total Number of patients (2010-2017)	Temperature	% Attributed to Temperature	Relative Humidity	% Attributed to Relative Humidity	Total Contribution from Two Parameters
Age 0-4	143	6	4.20%	0	0.00%	6
Age 5-9	447	0	0.00%	0	0.00%	0
Age 10-19	963	98	10.18%	88	9.14%	186
Age 20-44	983	0	0.00%	182	18.51%	182
Age 45-64	273	0	0.00%	20	7.33%	20
Age 65-69	36	0	0.00%	1	2.78%	1
Age 70+	28	0	0.00%	0	0.00%	0
Total	2873	104	3.62%	291	10.13%	395

From table 4 above

- Increase in temperature made population of the age 0-4 years to be vulnerable to the risk of epilepsy mental ill-health than increase in the relative humidity i.e. Out of 143 number of age 0-4 years patients visited the hospital in year 2010-2017, 4.20% of the 143 number of patients diagnosed were traceable/attributed to increases in temperature while none traceable to increase humidity.
- Out of 447 number of age 5-9 years patients visited the hospital in year 2010-2017, none were traceable to increase in temperature and relative humidity.
- Increase in temperature made population of the age 10-19 years to be vulnerable to the risk of epilepsy mental ill-health than increase in the relative humidity i.e. Out of 963 number of age 10-19 years patients visited the hospital in year 2010-2017, 10.18% of the 963 number of patients diagnosed were traceable/attributed to increases in temperature

while 9.14% were traceable/attributed to relative humidity.

- Increase in the relative humidity made population of the age 20-44 years to be vulnerable to the risk of epilepsy mental ill-health than increase in the temperature, the same applicable to age 45-64 years and 65-69 years i.e.
 - Out of 983 number of age 20-44 years patients visited the hospital in year 2010-2017, 18.51% of the 983 number of patients diagnosed were traceable/attributed to increases in relative humidity while none were traceable/attributed to temperature.
 - Out of 273 number of age 45-64 years patients visited the hospital in year 2010-2017, 7.33% of the 273 number of patients diagnosed were traceable/attributed to increases in relative humidity while none were traceable/attributed to temperature

- Out of 36 number of age 65-69 years patients visited the hospital in year 2010-2017, 2.78% of the 36 number of patients diagnosed were traceable/attributed to increases in relative humidity while none were traceable/attributed to temperature
- Out of 28 number of age 70+ years patients visited the hospital in year 2010-2017, none were traceable/attributed to increase temperature and relative humidity

5. Discussion

It was discovered in this study that different age groups respond differently to the impacts of increase in temperature and relative humidity. Their vulnerability to the risk of epilepsy as temperature and relative humidity increases differs

- Increase in temperature made population of children aged (0-19) more vulnerable to the risk of epilepsy mental ill-health than the increase in the relative humidity i.e. Out of 1553 number of age 0-19 years (children) patients that visited the hospital in year 2010-2017, 6.70% of the 1553 number of (children) patients diagnosed were traceable/attributed to increase in temperature while 5.67% were traceable to relative humidity or considering the grand total of epilepsy patients that visited the hospital 2010- 2017 was 2873, 3.62% traceable to increase in temperature are mainly from children aged population while 3.06% traceable to relative humidity are mainly from adult aged.
- Increase in relative humidity made population of adult aged (20-64) more vulnerable to the risk of epilepsy mental ill-health than the increases in the temperature i.e. Out of 1256 number of age 20-64 years (adult) patients visited the hospital in year 2010-2017, 16.08% of the 1256 number of adult aged patients diagnosed were traceable/attributed to increase in relative humidity while none were traceable to temperature or consider the grand total of epilepsy patient visited the hospital 2010- 2017 was 2873, only 7.03% traceable to increase in relative humidity are from adult aged population while none traceable to temperature.

According to Epilepsy Society (2018) epilepsy can start at any age including childhood and that in UK epilepsy affects around 1 in every 200 children and young people under 18. Also According to Beighi E et al (2018). The largest burden has been documented in children (0-19 years) aged and young adults (or adults age, 20-64 years). The burden as we see in this study can be trigger by the increase in both climate parameters (temperature and humidity). The increase in the temperature can be an additional burden on those age groups to trigger epilepsy. The elderly aged are not so much vulnerable to the risks of epilepsy with increase in the two parameters, but some literature has proved that epilepsy mental ill-health increase in the elderly can be attributed to the increase of age-related and aging -related epileptogenic conditions (Beighi E et al 2018). Also Patricia (2014) explained that, the rate of new cases of epilepsy is also high in people over age 55 and that older adults are more likely to have a stroke or develop brain tumors or Alzheimer's disease,

which can all cause epilepsy According to Jeanne Morrison (2017) epilepsy can developed at any age. Diagnosis usual occurs in the early childhood or after age 60. This actually falls within children group and adults aged in line with our results. It is an indication that increases in temperature and relative humidity can trigger epilepsy mental ill-health in those groups. The chance of people developing epilepsy increases the risks of age 20 from 2 to 5 percent and those with parent whose epilepsy is linked to genetics can be aggravated by external force such as increase in the temperature and relative humidity followed "Causal theories of mental disorders". Victims of those epilepsy symptoms at age 20 above can be strongly affects by increase in the two climate parameters. What increase in the two climate parameters does is to activate some of the symptoms. The positive contribution from the two climate parameters as strong external forces elevated vulnerability and symptomatology risks of epilepsy mental ill-health. According to Patricia O S (2014) Epilepsy and seizures can develop in any person at any age and it more common in young children and older people and that the risk is higher for people with certain condition. According to Mayo Clinic Staff (2019) researchers have linked some types of epilepsy to specific genes or it's likely that there's a genetic influence and that the onset of epilepsy is most common in children and older adults, but the condition can occur at any age, also people with family history of epilepsy may be at an increased risk of developing a seizure disorder, in addition certain anti-epilepsy medications used by epileptic woman during pregnancy increase the risk of birth defects and also according to Epilepsy Society (2018) some researchers now believe that the chance of developing epilepsy is probably always genetic to some extent, in that anyone who starts having seizures has always had some level of genetic tendency to do so.

According to Zack MM et al (2017) about 3 million US adults aged 18 years or older have active epilepsy and that 1 million of those adults are aged 55 or older (Sapkota S et al 2018). When we now further consider the 395 total number of epilepsy patient traceable/attributed to the two parameters, we discovered that the number of children age (0-19years) were 192 (48.61%) in numbers and for the all adult aged (20-69 years) were 203 (51.39%) in numbers. By our own age stratifications the adult's age are more vulnerable to the risk of epilepsy cases than the children aged. So epilepsy can affect people at any age, but it's more likely to develop in adults. Also Patricia (2014) explained that, the rate of new cases of epilepsy is also high in people over age 55 and that older adults are more likely to have a stroke or develop brain tumors or Alzheimer's disease, which can all cause epilepsy

6. Conclusion

There are positive associations between the number of epilepsy- mental ill-health patients and the rate of hospital visits among age groups in relation to the increase in the two parameters. The positive contributions from the two climate parameters in the number of patients among those age groups with epilepsy psychiatric cases and the rate of hospital visits indicates that increase in the temperature and relative humidity made groups vulnerable to epilepsy mental ill-health.

Increase in temperature made children aged population vulnerable to the risk of epilepsy - mental ill-health while increase in the relative humidity made adult aged population vulnerable to the risk of epilepsy- mental ill-health. Different age groups respond differently to the variations in the two parameters and they are vulnerable to the risks of epilepsy psychiatric mental ill-health differently as the two parameters increases. It also an indication that the nature of responses of various age groups to change in temperature is different from the change in the relative humidity. The degree of their response that generated epilepsy mental ill-health differs since temperature affect one group than others also with the relative humidity. Epilepsy develops more with those adult aged than the children aged.

Between the eight (2010-2017) years increase in the relative humidity spread epilepsy mental ill-health among age groups population more than increase in the temperature i.e. the vulnerability and susceptibility of population at the risks of epilepsy mental ill-health are higher as relative humidity increases than when temperature increases. Out of total population of 2873, 10.13% of the patients were attributed to the increase in relative humidity and 3.62% were attributed to increase in the temperature. Even relative humidity spread epilepsy epidemic across age 10-64 with middle interval of 36.5 or value distance range of 36, while temperature spread epilepsy epidemic only across age 0-19 with middle interval of 10 or value distance range 19. The higher the middle interval or the greater the value distance range the more the spreading.

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