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Original Work

Seasonality in hyperglycemic emergencies in a Health Facility in Sub-Saharan Africa: The roles of geographic location, infection, and knowledge of diabetes mellitus status

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ABSTRACT: Hyperglycemic emergencies (HEs) are acute complications of diabetes mellitus and they carry high morbidity and mortality. Studies have reported a seasonal pattern in the frequency of occurrence of both types 1 and 2 diabetes mellitus and even Gestational Diabetes Mellitus. No such association has been suggested for HEs. The study was conducted at the Asokoro District Hospital, Located in Abuja, Nigeria to examine a seasonal pattern in the frequency of hyperglycemic emergencies. The initial observation of an obvious fluctuation in the number of admitted cases of hyperglycemic emergencies motivated this prospective study which ran for a period of six years. It involved collecting the relevant information using a questionnaire from all HEs patients admitted to the medical ward from the first of January, 2008 to the 31st of December, 2013. Required investigations were done. The precipitating factors for HEs were looked for. The number of cases per month was noted for each year. The Statistical package used for analysis was STATA version 11. Round the year Abuja Climatic changes were monitored on the website of the Nigerian Meteorological station. Four hundred and fifty-one (451) patients with hyperglycemic emergency were enrolled for this study. Most of the patients, (55%), were in the middle-age bracket. Fifty-six per cent (56%), were not previously known to be living with diabetes mellitus. Infections, particularly of the respiratory and gastrointestinal tracks, were the commonest precipitating factors. Variation in the frequency of HEs was observed, with two peaks: one in April and a smaller peak in December. There is seasonal variation in the frequency of presentation of Hyperglycemic emergencies. This may have been influenced by exogenous factors such as geographic location, infection, and the fact that most of the patients never knew they had diabetes mellitus.

KEY WORDS: ***Hyperglycemic emergencies; Seasonal pattern; Geographic location; Diabetes mellitus***

INTRODUCTION

Diabetes mellitus (DM) has assumed pandemic proportions of public health concern[1,2]. It is projected to be more evident in the developing countries of Africa and Asia[1-4]. DM is often associated with a high disease burden in areas where there is poor accessibility to health facilities such as in Africa, with consequent high case fatality rates, especially when presenting in emergency states such as hyperglycemic emergencies (HEs)[5].

HEs are acute complications of diabetes mellitus that may be life threatening, requiring prompt

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recognition, diagnosis and appropriate treatment intervention, and often drawing significant financial and human resources[6,7]. As with communicable diseases, non-communicable diseases, including DM and its acute complications such as HE, may present a higher disease burden with more strain on available health-care resources during periods of higher encounters[8].

Earlier reports have suggested that, the prevalence of types 1 and 2 DM may vary with season being influenced by certain interfacing environmental factors[8-10]. Such factors which are characterized as endogenous and exogenous include infections, which may be influenced by the prevailing season, and location[11,12]. There is paucity of data that describe variation of HEs with season in Nigeria. This study examined the frequency of presentation of HEs in different seasons in Nigeria, a sub-Saharan African (SSA) country.

METHODOLOGY

An ethical clearance for the study was obtained from the Asokoro District Hospital (ADH) Research and Ethics committee. Informed consent was obtained from each patient for this study. The study was a prospective one, which ran for six years from January, 2008 to December, 2013. All patients with Hyperglycemic emergency admitted at the Asokoro District Hospital, Abuja, within that period were recruited. A questionnaire was completed for each patient at time of admission and discharge. Clinical examinations and investigations were done accordingly. The information obtained include biodata, plasma glucose and electrolyte levels, duration of DM for those previously known to be living with diabetes mellitus and the treatment-type received prior to hospital admission. Ketonuria was estimated using dip sticks.

Operational Definitions: Type I DM referred to DM patients who have been on insulin since diagnosis and require insulin for survival. Type 2 DM referred to patients with DM who were previously managed solely on lifestyle modification, and/or on oral hypoglycemic agents. It also encompasses insulin-requiring patients who initially did not depend on insulin. Diabetes Ketoacidosis (DKA) referred to blood glucose levels >13.8 mmol/L and the presence of metabolic acidosis (bicarbonate levels of <10 mmol/L-18 mmol/L) and or the presence of ketonemia or ketonuria[13,14]. Hyperosmolar Hyperglycemic State (HHS) referred to plasma glucose levels of >33.3 mmol/L and bicarbonate levels of >18 mmol/L with or without the presence of ketonuria[13,14].

Duration of DM was categorized into unknown, and short duration, which referred to those that have had DM for 0<5 years, medium duration, which referred to DM duration of 5–10 years, and long standing referring to DM duration of more than 10 years. Round the year Abuja, climatic changes were monitored on the website of the Nigerian Meteorological station[15]. The temperature pattern of Abuja was corroborated by Orisakwe *et al.*[16] and displayed in **figure 1**.

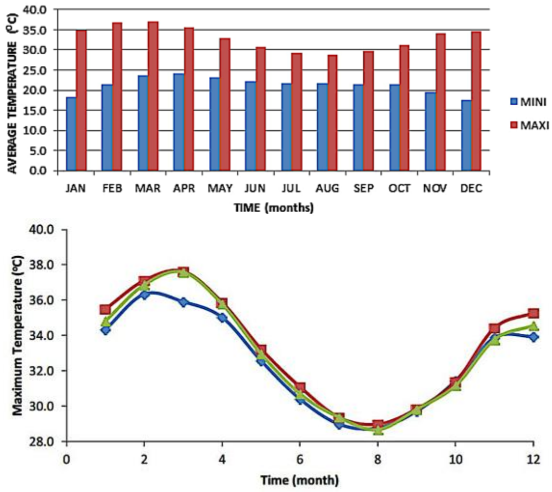

Figure 1: Temperature pattern in Abuja

The Statistical package used for analysis was STATA version 11. The Statistical tests used were Student's t-test and $\chi 2$ for analysis of continuous and categorical data, respectively. Two-sided 2 sample test of proportions was used to compare difference in the proportion of patients presenting during the hypothesized peak seasons. Significance level was set at a p value <0.05

RESULT

Four hundred and fifty-one (451) patients were admitted and managed for hyperglycemic emergencies at the Asokoro District Hospital, Abuja, during the study period.

Table 1 shows the characteristics of these patients. Most of the patients (55%) were in the middle-age bracket. The patients marked as unknown, (56%), were those who were not previously known diabetic patients, presenting for the first time in emergency, hence not routinely on any clinic or hospital diabetes-register. However, twelve of them were later found to have taken across-the-counter oral hypoglycemic agents before, and have "rejected" the disease because they believed they were free of DM. This number (12) was also considered under the group of patients with poor compliance to treatment. Most presentations were with DKA (76%). Fifty-three per cent (53%) of the patients were also hypertensive.

Table 2 displays the identified precipitating factors for HE. They were infections, particularly

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respiratory tract infection (RTI) 40.72%, urinary tract infection (UTI) 30.32%, and gastrointestinal infection (GII) 15.84%. Blood film was positive for malaria parasite in about 11% of patients. Sepsis and stroke were identifiable factors in 2.26% and 0.23%, respectively.

Table 3 shows the frequency and proportion of patients presenting with respiratory tract infection (RTI). The months of February, April, May, and December had the highest proportions of patients presenting with RTI. On conducting a statistical test of proportions, April and May were found to be statistically significant, higher than other months of the year. P value was less than 0.05 for all tests of comparison done. The overall (male and female) mean blood sugar at entry and on discharge were 25.39 mmol/l ± 7.24SD and 7.51mol/l ± 2.89SD, respectively. Mean glycated hemoglobin was 10.23 ± 1.86SD.

Figure 2 displays the percentage distribution of patients per month. The number rose rapidly from March, peaked in April and started declining with its trough around September. There was a second, but smaller peak around December that year and January the following year.

Table1. Characteristics of patients

	Females n(%)	Males n(%)	%Overall(N=451)	P value
Age				
<45yrs	72(47)	81(53)	34	0.000
45-64yrs	72(29)	176(71)	55	
>64yrs	29(58)	21(42)	11	
Duration of DM				
Unknown	83(23)	170(67)	56	
0-4years	43(43)	57(57)	22	
5-10years	33(49)	34(51)	15	
>10years	14(45)	17(55)	7	
HE Type				
HHS	58(54)	50(46)	24	0.000
DKA	115(47)	228(53)	76	
Hypertension	82(34)	159(66)	53	0.038
Patient Type				
ADH patient	16(25)	46(75)	14	0.000
Non ADH patient	75(54)	63(46)	30	
Not Registered	82(33)	169(67)	56	
BMI				
<18.5	9(45)	11(55)	4	0.566
18.6- 24.9	71(39)	113(61)	41	
25-29.9	71(67)	106(33)	39	
>30	22(31)	48(69)	16	
Compliance				
Good Compliance	10(26)	28(74)	18	0.074
Poor Compliance	73(42)	101(58)	82	
Ketonuria				
None	119(42)	224(58)	24	0.004
≥+1	54(50)	54(58)	76	

Table 2: Precipitating factors of hyperglycaemic emergencies

	Females n(%)	Males n(%)	%Overall	P value
RTI	63(35)	117(65)	40.72	
UTI	60(45)	74(55)	30.32	
GI infection	38(54)	32(46)	15.84	0.000
Malaria	6(13)	41(87)	10.63	
Sepsis	4(40)	6(60)	2.26	
Stroke	0(0)	1(100)	0.23	

Table 3: Proportion of patients presenting with respiratory infection as the precipitant of the hyperglycemic emergency

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Freq	17	10	21	42	28	17	7	9	3	6	6	14
Prop	0.39	0.46	0.39	0.47	0.43	0.38	0.35	0.45	0.02	0.38	0.33	0.41
C.I	.24,.53	.24,.67	.26,.52	.37,.58	.31,.55	.23,.52	.13,.57	.23,.67	.01,.41	.13,.62	.10,.56	.24,.56

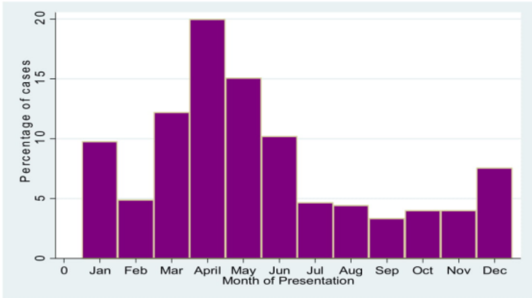

Figure 2: Patients distribution by month

DISCUSSION

Hyperglycemic Emergencies (HEs) are acute complications of diabetes mellitus that may be life threatening, requiring prompt recognition, diagnosis and appropriate treatment interventions[6,7]. Season and location have been shown to influence patterns of disease presentation[8,11,12]. With respect to location, Abuja (the very center of Nigeria,) lies approximately within latitudes 4^0N and 14^0N and within longitudes 3^0E and 15^0E[17]. Available literature highlights the climatic implication of this location in the West African sub region[18] i.e., the geographic space of Abuja is widely exposed to the influence of approaching desert winds, sandstorms, and high radiation resulting in high temperatures from the north[17,18]. Furthermore, Abuja is situated in this unique region that extends from the upper half of the middle belt terminating at the upper Sahel Savanna demarcation[19] with characteristic high sunshine, low clouds, reduced evaporation, and high diurnal temperatures which routinely ranges between 29^0C and 43^0C[17,19]. This type and similar variation in tropical climatic conditions have been observed to influence the incidence of DM[19-22]. Available literature has clearly demonstrated seasonality in certain diabetes related complications such as hyper- and hypoglycemia in some tropical regions[22] and temperate regions[23]. Such variations have not been reported in Nigeria and the Sub-Saharan region.

Seasonal variation in the rate of presentation of HEs is clearly demonstrated by our study (figure 2). It showed variation in the number of encounters of hyperglycemic emergencies with seasons of the year. Notably, two peaks were observed in the rates of presentation. The first peak was around March/April. A rise was observed from March, peaks in April and then dropped. Interestingly, an attempt at superimposing figure 2 on figure 1[16]

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reveals that the months with highest cases almost coincided with the months with highest temperatures from February to April. Thus, the effect of the rising temperatures starting from February begins to manifest in March and April of the same year. How could this be explained?

Notably, the risk for dehydration is high during periods of high temperatures, and low humidity[24]. Also, infections, particularly respiratory tract infections, are also encouraged by high temperatures[25]. In our study, respiratory tract infection was the commonest infection type seen among our patients during the first peak (table 3). This is significant as infection is a known precipitant for HEs[26-29]. Infections, particularly respiratory infections are frequent and may increase the chances of decompensation of hyperglycemia.

Since the peak period coincided with periods of high temperatures, it is possible that these patients, especially those who never knew they had diabetes mellitus, and thus had poor or no knowledge of diabetes were dehydrated. In the setting of high temperatures, were at high risk for infections, and consequently came down with HEs. It is also known that extreme temperatures may affect insulin viability[30-32] especially if storage systems are poor, particularly in settings of poor electric power supply such as ours[33] often experiencing a break in the cold chain. This is also true for pen-insulin stored in the refrigerator[31,32] accounting for poor control among the insulin-treated patients, with inadvertent decompensation, particularly when infection sets in.

Although respiratory tract infection was the commonest type of identified infection, gastroenteritis also occurred. The peak periods for HEs coincided with periods of poor water supply in the suburbs where most of these patients live and come from, namely, ***Maraba, Nyanya*** and ***Mpape***. These are residential areas for mainly low-income earners with poor utilities such as poor water supply, poor infrastructure, and overcrowding. These conditions may fuel respiratory and gastrointestinal infections with high risk for decompensation of DM.

One clinical feature of hyperglycemia is tiredness, thought to be sequel to metabolic derangement, particularly hypokalaemia[34]. Since most of the patients (53%), never knew they had DM, and since it is common practice here to ingest energy/soft drinks when people feel "tired"[35], these patients who also feel thirsty, tend to ingest lots of soft drinks in their quest for energy and rehydration. This has the potential of making their blood sugar levels much higher at time of presentation.

There was a second, but smaller peak around December-January before dropping again. When examined side by side the temperature pattern[16], it almost coincided with the harmattan haze, which is characterized by dust and dryness[36]. These are unfavorable weather conditions that also encourage infections, particularly of the respiratory tract[24-29,37]. When infection sets in, the risk for glycemic decompensation increases[26-29]. These findings appear to corroborate the suggestion that glycemic control in diabetes mellitus depends on both endogenous and exogenous factors[8], which include infection and seasonal change.

Our study findings appear to differ, partly, from earlier studies from other regions, tropical[22] and non-tropical[23]. While our study showed a linear relationship between the rate of HE and rising temperatures in a SSA setting, Lu *et al.*[22] in a study in Taiwan, also with tropical climatic conditions, reported an inverse relationship. On the other hand, in a temperate region, Clemens *et al*[23] in a study in Ontario Canada, showed a peak in HE encounters in January which is a winter-month in that city. In our study, we found a second peak in December/January, figure 2, when Abuja experiences harmattan-haze. Harmattan period is characterized by dust and dryness[36]. Interestingly, January which is a winter month in Ontario, Canada, and dry harmattan period in Abuja, Nigerian, is characterized by high risks for infections, particularly of the respiratory tract[24-28,38], a precipitant of HE. The Canadian study also reported seasonality in hypoglycemic encounters.

Irrespective of the pattern of HE encounters with season, the clinico-epidemiologic importance may include highlighting periods of vulnerability for diabetes patients, inform future epidemiological studies, and aid in the appropriate planning of healthcare resources.

Our study, supported by previous ones, has provided sensitization on the possible factors responsible for the seasonal encounters of diabetes mellitus, and HEs. The prevention of diabetes and HEs occurring, including the associated environmental factors, may therefore need to be intensified and seasonally adapted.

CONCLUSION

There is seasonality in the frequency of presentation of hyperglycemic emergencies in Abuja, North Central Nigeria. There are two peaks per year cycle during which most patients present. These peaks coincide with periods of dryness and extreme temperatures, or associated poor utilities, with high infection risks/rates that readily precipitate emergency presentation in these patients, most of whom had no knowledge of their status of diabetes mellitus.

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