Biological and Environmental Sciences Journal for the Tropics 9(1), March, 2012 ISSN 0794 – 9057

BEST JOURNAL 9(1): 145 - 153
Date received: December 28, 2011
Date accepted: February 01, 2012
Printed in Nigeria

EPIDEMIOLOGY OF HUMAN *ROTAVIRUS* INVOLVED IN GASTRO-INTESTINAL AMONG CHILDREN IN THREE NORTH-CENTRAL STATES AND FEDERAL CAPITAL TERRITORY ABUJA, NIGERIA

***[1]Kuta, F.A., A. Uba[2], O.M. Oyawoye[2], I.Z. Yusuf[2], N.U. Adabara[1] and A.J. Momoh[1]**
[1]Department of Microbiology, Federal University of Technology, PMB 65, Minna, Niger State, Nigeria
[2]Biological Sciences Programme, Abubakar Tafawa Balewa University, PMB 0248, Bauchi, Nigeria
*Correspondence author

ABSTRACT

A total of six hundred (600) stool samples collected from children and infants (0-5 years) presenting with diarrhea at the various hospitals located in three North Central States of Nigeria and the Federal Capital Territory, Abuja were screened for rotavirus antigens using Enzyme Linked Immunosorbent Assay (ELISA). Twenty seven (4.5%) were found to be positive. The prevalence of rotavirus infection among children in the rural areas in Niger State was 1.7%, Kwara State 0.7%, Nasarawa State 0.7% and FCT 2.5%. The children that reside in urban areas in Niger State recorded 0.6%, Kwara State 1.3%, no positive case was recorded for Nasarawa State and FCT 1.6%. The distribution of the infection among children within the age group <1-2 yrs in Niger State was 1.7%, Kwara State 1.4%, none for Nasarawa State and FCT 2.8%. The children within the age group of 3-5 yrs in Niger State had 0.7%, Kwara State 0.7% Nasarawa State 0.7% and FCT 1.3%. The male children in Niger State had 0.9%, Kwara State 0.9%, Nasarawa State 0.4% and FCT 1.5%. The female children in Niger State recorded 1.5%, Kwara State 1.1%, Nasarawa State 0.4% and FCT 2.5%. The prevalence of infection among the children in the study area during the dry season indicated Niger State had 2.3%, Kwara State 1.9%, none for Nasarawa State and FCT 3.2%. In the rainy season Niger and Kwara states recorded no incidence. Nasarawa State and FCT had 0.7% each. The children whose parents are civil servants recorded 1.4% in Niger State, Kwara State 0.9%, none for Nasarawa State and FCT 1.4%, whose parents are into business in Niger State had 1.1%, Kwara State 0.4%, Nasarawa State 0.4% and FCT 1.5%. The prevalence of infection among children of the farmers/low income earners was Niger State 0.9%, Kwara State 2.6%, Nasarawa State 0.9% and FCT 4.4%. Children that drink water from tap/boreholes had prevalence of 1.7% in Niger State, Kwara State 0.7%, Nasarawa State had no positive case and FCT 1.4%. Those that drink water from streams/rivers had 0.7% in Niger State, Kwara State 1.3%, Nasarawa State 0.7% and FCT 2.6%. The prevalence of rotavirus infection among children that have pit/flush latrine in their houses in Niger State was 0.7%, Kwara State 0.7%, none for Nasarawa State and FCT 1.8%, while those that lack toilet facilities in their houses recorded as follows; Niger State 1.6%, Kwara State 1.3%, Nasarawa State 0.6% and FCT 2.2%. The result of the regression analysis indicated that factors such as age, sex, location of residence, seasonal variation, source of water and toilet facilities were found not to have statistically significant influence on the rate of infection($p>0.005$).

Keywords: Rotavirus, Gastroenteritis, Diarrhea, Vaccine, Children, Epidemiology, North-central, Nigeria.

INTRODUCTION

Rotavirus is a genus of double stranded RNA virus in the family of Reoviridae. It is the leading single cause of severe diarrhea among infants and young children and is one of the viruses that cause infections commonly known as stomach flu, despite no relation with influenza virus (Dennehy, 2008). Globally over 500,000 – 870,000 children between 0 – 5years die every year from rotavirus gastroenteritis, with vast majority of these deaths occurring in the developing nations. In developed countries, rotavirus infection rarely results in death but remain the most common cause of hospitalization for acute gastroenteritis in children and leads to major medical and societal costs (Aminu *et al.*, 2008).

In 1998-2000, several generations of vaccines against rotavirus such as RotoTeq, WC3-QV, LLR, RV3, Rotarix, 116E and 1321 were produced and approved by the United States Food and Drug Administration and recommended for inclusion in the 1999 U.S schedule for routine childhood immunization and other parts of the developing countries.

ISSN 0794 – 9057

In July 1999, these vaccines were withdrawn from circulation worldwide following reports of cases of intussusceptions among recently vaccinated children (Widdowson *et al.,* 2005). Since 1999, several important developments have improved the understanding of the natural history of rotavirus infection and intussusceptions, as well as the disease burden of rotavirus associated gastroenteritis. Efforts to develop a more potent and safe vaccine of intussusceptions gave birth to withdrawal of the above mentioned multiple vaccines (Widdowson *et al.,* 2005).

Epidemiological studies of rotavirus infection conducted in Nigeria revealed that, the prevalence of rotavirus gastroenteritis is about 27% (Gomwalk *et al.,* 1993). Similarly, studies by Aminu *et al.* (2009) indicated a prevalence of 9% in the North western Nigeria and 27% in part of the North Central State (Plateau State) (Gomwalk *et al.*, 1990). Efforts are on-going by the World Health Organization and Africa Regional Network for rotavirus studies to reduce the disease burden through vaccine development, but this has been hampered due to continuous emergence of new strains (possible genetic re-assortment), this has created the scenario of genetic diversity of the virus in different regions of Africa. This ugly situation has continued to hinder the development of potent vaccine that could be used to stem the scourge of rotavirus gastroenteritis in Nigeria, and indeed other parts of Africa (Aminu *et al.,* 2008).

The study areas and methods

Three states from the North Central geo- political zone and the FCT of Nigeria were chosen for the study, because there is little reports on the epidemiology of human *rotavirus* in the states selected. The States were Niger, Kwara and Nasarawa.

Federal Capital Territory (Abuja)

The Federal Capital Territory is the home of Abuja, the Capital of Nigeria. The Territory was formed in 1976 from parts of Nasarawa, Niger and Kogi States. It is in the central region of the country. Unlike the states of Nigeria, which are headed by elected Governors, it is administered by the Federal Capital Territory Administration headed by a Minister (Wikipedia, 2008).

The Territory is located just north of the confluence of the Niger and Benue rivers. It is bordered by the states of Niger to the West and North, Kaduna to the North East, Nasarawa to the East and South and Kogi to the South West. The FCT lies between latitude 8.25^0 and 9.20^{0}N of the equator and longitude 6.45^0 and 7.39^{0}E of Greenwich Meridian. Abuja is geographically located in the center of the country. The federal Capital Territory has a land mass of approximately 8000 square kilometers of which the actual city occupies 250 square kilometers. It is situated within the savannah region with moderate climatic conditions. It has population of 1,405,201 (2006 Census). The territory is currently made up of six area councils (Wikipedia, 2008).

Niger State

It is a state in the north central part of Nigeria and the largest state in the country. The state capital is Minna. The state was created on 3rd February, 1976 from the defunct North Western state. It has a land area of 76, 363 square kilometers and has a population of 4,082,558 million people with 25 local government areas (2006 Census). The state is named from the River Niger. Two of Nigeria's major hydroelectric power stations- the Kainji and the Shiroro Dams- are located in Niger State. Also situated there is Kainji National Park, the largest National park in Nigeria, which contains Kainji lake (Wikipedia, 2008).

Kwara State

Kwara state was created on 27 May 1967, when the Federal Military Government of General Yakubu Gowon broke the four regions that then constituted the federation of Nigeria into 12 states. At its creation, the state was made up of the former Ilorin and Kabba provinces of the then Northern Region and was initially named the west central state but later changed to "Kwara" a local name for the River Niger (Wikipedia, 2008).

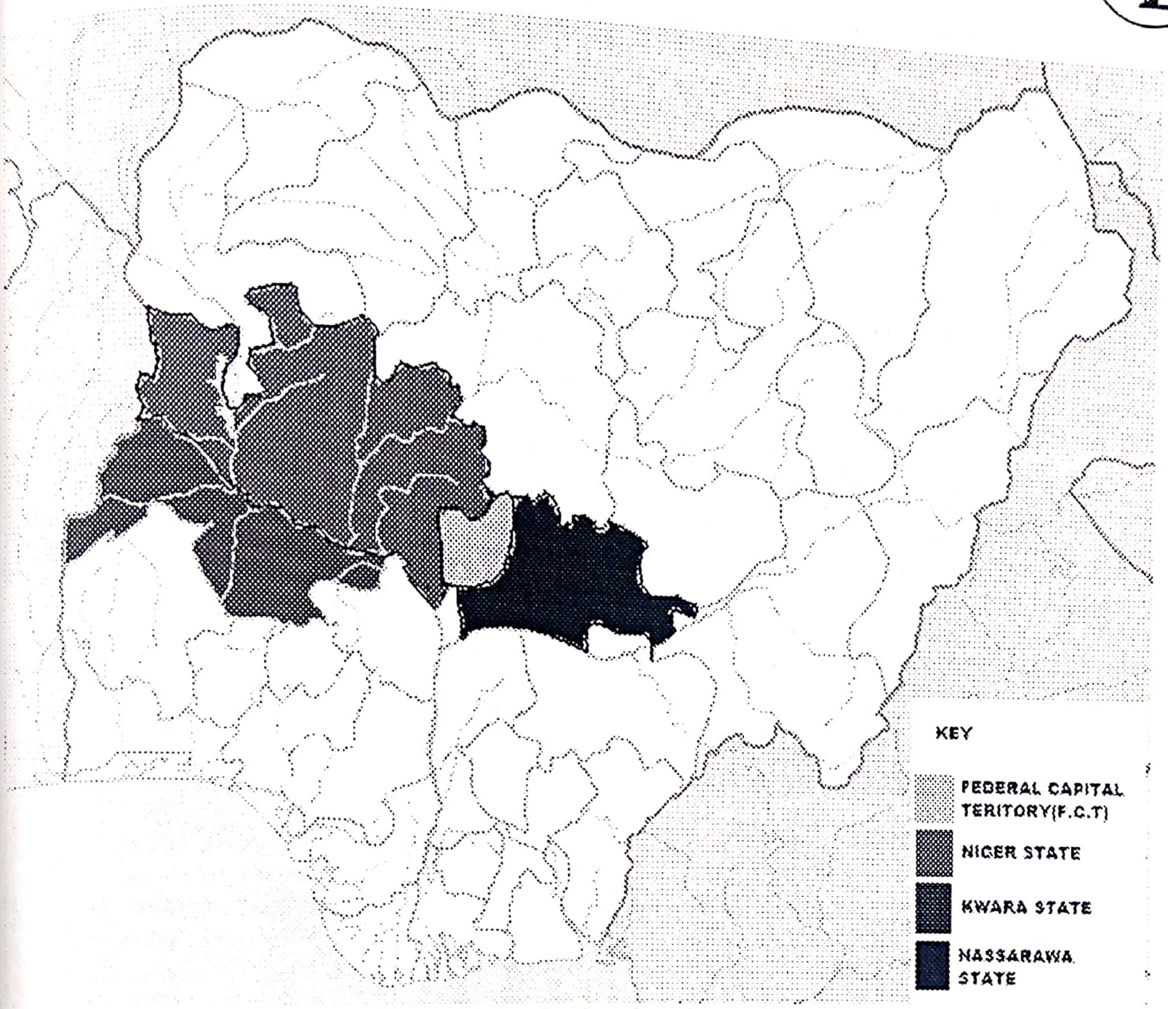
Kwara State has its capital at Ilorin. It has a land area of 36,825 square kilometers and a human population of 2,591,555 (2006 Census). Kwara state has since 1976 reduced considerably in size as a result of further state creation exercises in Nigeria. On 13 February 1976, the Idah and Dekina parts of the state were carved out and merged with a part of the then Benue/Plateau state to form Benue state. The state has sixteen local government areas. The primary ethnic group of Kwara state is Yoruba, with significant Nupe, Bariba and Fulani minorities (Wikipedia, 2008).

Nasarawa State

Nasarawa State is a state in north central Nigeria. Its capital is Lafia. Nasarawa State was created on 1st October, 1996 from Plateau state. The state is bounded in the north by Kaduna state, in the West by the Federal Capital Territory, in the south by Kogi and Benue States and in the east by Taraba and Plateau states (Wikipedia, 2008).

The State has a land area of 27, 117 square kilometers with a population of 2,040,097 (2006 Census). It has thirteen local government areas and is endowed with mineral deposits such as salt and bauxite (Wikipedia, 2008).

Biological and Environmental Sciences Journal for the Tropics 9(1), March, 2012
ISSN 0794 – 9057



Map of Nigeria showing the study areas.

Sample Size

The sample size of the stool samples collected for the research work was determined by the formular below.

$$n = \frac{t^2 \times p(1-p)}{m^2}$$ (Aminu *et al.*, 2009).

Where,

n = Required sample size
t = Confidence level at 95% (standard value of 1.96)
p = Prevalence rate of the disease (9%)
m = Margin of error at 5% (Standard value of 0.05)

p = 9% = 0.09
t = 1.96
m = 0.05

$$n = \frac{1.96^2 \times 0.09(1-0.09)}{0.05^2} = \frac{3.84 \times 0.09(0.91)}{0.0025}$$

$$= \frac{0.314496}{0.0025} = 125.8 \approx 126$$

NB: Minimum of 150 stool samples were collected per state and the FCT.

Sample collection

A total of six hundred (600) stool samples were collected from children (0-5years) that presented with diarrhea in the Paediatric Departments of the primary, secondary and tertiary hospitals located in parts of the three States and FCT that constituted the study area. The states include Niger, Kwara, Nasarawa and, the Federal Capital Territory, Abuja.

ISSN 0794 – 9057

The number of samples collected from each hospital in each of the three states and the FCT was Niger state : General hospital Mokwa 22, Minna General hospital 30, Bida General hospital 23, Federal Medical Center Bida 30, Kontagora General hospital 25, and Suleja General hospital 20; Kwara State: University of Ilorin Teaching Hospital 78, and General hospital Ilorin 72; Nasarawa State: General hospital Keffi 56, Rural Health Center Akwanga 43, Federal Medical Center Keffi 51; and FCT: National Hospital, Abuja 82, Mogadishu Military Hospital 68. The sample collection was done from November, 2008 to October, 2009. The samples were collected (Aminu *et al.,* 2009) after seeking a written consent from the parents/guardians of the target group. Demographic information was also collected using questionnaire (Mishra *et al.,* 2010) which included: season of sample collection (rainy or dry season), location of residence (rural or urban), sex (female or male), age (<1-2 yrs and 3-5 yrs), source of water (pipe bone water, borehole or stream/river), toilet facilities (pit or flush latrine) and occupation of the parents/guardian of the children. The stool samples were collected in sterile sample bottles and transported to the Department of Microbiology, Faculty of Science, Ahmadu Bello University (ABU), Zaria and stored in the freezer at -20^{0}C until use.

Preparation of Dilution Buffer/ Wash Solution

Five hundred milliliters (500 ml) concentrate buffer was added to 500 ml of distilled water and was mixed thoroughly to obtain a balanced solution of 1000 ml. This was used as solvent to dissolve the stool samples in preparation for ELISA screening.

Preparation of Stool Samples for Enzyme Linked Immunosorbent Assay (ELISA)

The six hundred (600) frozen stool samples were thawed and each diluted to a ratio of 1:5 by adding 1gram of stool sample to 4 ml of dilute dilution wash buffer in each case. These were mixed thoroughly and allowed to settle and the supernatants collected and used for the ELISA screening (Dennehy and Penelope, 1990).

Enzyme Linked Immunosorbent Assay (ELISA)

Each of the six hundred (600) stool samples was screened (Aminu *et al.,* 2008) as follows: One hundred microliters (100 µl) of positive control reagent was introduced into wells two and three of the 96 titre plates. Also, 100 microliter of negative control reagent was introduced into wells four and five. From well six to the 96th well, 100 µl of the supernatant phase of test stool samples were separately introduced and then incubated at room temperature for 30 minutes. The wells were washed with dilution buffer solution (wash solution). Two (2) drops of reagent one (blue solution) was introduced into each of the wells except well one (blank). It was then incubated at room temperature for 5 minutes and was rinsed with wash buffer. Two (2) drops of reagent two (red solution) was introduced into each well and was incubated at room temperature for 5 minutes, and then washed again. Two drops of chromogen was added to each well and was mixed thoroughly using tapping strip holder. Finally two drops of stop solution was added into each well and was mixed. Visual observation and readings from spectrophotometric and bichromatic device was done and recorded.

RESULTS

Out of the six hundred (600) stool samples collected from children and infants (0 – 5 yrs) that presented with diarrhea and examined for rotavirus antigens by Enzymes Linked Immunosorbent Assay (ELISA), twenty seven representing 4.5% were positive.

The prevalence of rotavirus infection among children living in rural areas in the three states of North Central Nigeria was Niger state, 1.7%, Kwara state, 0.7%, Nasarawa state 0.7% and the FCT, 2.5%. The number of stool samples collected from rural areas of the 3 states and the FCT was 284, out of which 16 representing 5.6% were positive for rotavirus antigens (Table 1).

Out of the 316 stool samples collected and screened from children living in urban areas, 11 were positive for rotavirus, out of which 0.6% were from Niger state, 1.3% from Kwara state, none from Nasarawa state and 1.6% from the FCT (Table 1).

Table 1 Distribution of rotavirus infection according to location of residence

Location (State)	No of sample screened (rural area)	No of positive sample (rural area)	Percentage Positive (%) (rural area)	No of sample screened (urban area)	No of positive sample (urban area)	Percentage Positive (%) (urban area)
Niger	80	5	1.7	70	2	0.6
Kwara	58	2	0.7	92	4	1.3
Nasarawa	79	2	0.7	71	-	-
FCT	67	7	2.5	83	5	1.6
TOTAL	**284**	**16**	**5.6**	**316**	**11**	**3.5**

FCT - Federal Capital Territory

Biological and Environmental Sciences Journal for the Tropics 9(1), March, 2012 ISSN 0794 – 9057

Out of the 291 stool samples collected and screened from children within age group of <1-2 years in the study area, 5.9% were positive for rotavirus, out of which 1.7% were from Niger state, 1.4% from Kwara state, none from Nasarawa State and 2.8% from the FCT (Table 2). Similarly from the 309 stool samples collected and screened from children within age group of 3-5 years, ten 3.4% were positive for rotavirus antigens, FCT had the highest prevalence of 1.3% and 0.7% each for all the states (Table 2).

Table 2 Distribution of rotavirus infection according to age

Location (State)	No of sample screened (<1-2years)	No of positive sample (<1-2years)	Percentage positive (%) (<1-2years)	No of sample screened (3-5yrs)	No of positive sample (3-5yrs)	Percentage positive (3-5yrs)
Niger	80	5	1.7	70	2	0.7
Kwara	60	4	1.4	90	2	0.7
Nasarawa	65	-	-	85	2	0.7
FCT	86	8	2.8	64	4	1.3
Total	291	17	5.9	309	10	3.4

Out of the 324 stool samples screened from male children, 3.7% were positive and distributed as follows: Niger state 0.9%, Kwara state 0.9%, Nasarawa state 0.4% and FCT 1.5% (Table 3). From the 276 stool samples screened from female children,5.5% were positive and distributed as follows: Niger state 1.5%, Kwara state 1.1%, Nasarawa state 0.4% and FCT 2.5% (Table 3).

Table 3 Distribution of rotavirus infection according to sex

Location (State)	No of sample screened(male)	No of positive (male)	Percentage (%) positive (male)	No of sample screened (female)	No of positive (female)	Percentage (%) positive(female)
Niger	90	3	0.9	60	4	1.5
Kwara	70	3	0.9	80	3	1.1
Nasarawa	64	1	0.4	86	1	0.4
FCT	100	5	1.5	50	7	2.5
Total	**324**	**12**	**3.7**	**276**	**15**	**5.5**

FCT - Federal Capital Territory

Out of the 309 stool samples collected during dry season, 7.4% were positive and distributed as follows: Niger state 2.3%, Kwara state 1.9%, none for Nasarawa state and FCT 3.2% (Table 4). From the 291 stool samples collected during rainy season, 1.4% were found to be positive and distributed as follows: Nasarawa and FCT recorded 0.7% each, the other states had none (Table 4).

Table 4: Distribution of Rotavirus infection according to season

Location (State)	No of sample screened (dry season)	No of positive (dry season)	Percentage(%) Positive (dry season)	No of sample screened (rainy season)	No of positive (rainy season)	Percentage(%) Positive (rainy season)
Niger	90	7	2.3	60	-	-
Kwara	80	6	1.9	70	-	-
Nasarawa	50	-	-	100	2	0.7
FCT	89	10	3.2	61	2	0.7
Total	**309**	**23**	**7.4**	**291**	**4**	**1.4**

FCT - Federal Capital Territory

Of the 222 stool samples collected from children of civil servants, 3.7% were positive with rotavirus antigens and distributed as follows: Niger state 1.4%, Kwara state 0.9%, none for Nasarawa state and FCT 1.4% (Table 4.5). Out of the 263 stool samples collected from children of business men and women, 3.4% were positive and distributed as follows: Niger state 1.1%, Kwara state 0.4%, Nasarawa state 0.4% and FCT 1.5% (Table 5), and from the 115 stool samples collected from children farmers, (8.8%) were positive and distributed as follows: Niger state 0.9%, Kwara state 2.6%, Nasarawa state 0.9% and FCT 4.4% (Table 5).

Table 5: Distribution of Rotavirus infection by social class

Location (State)	Civil servant Ns	Np	%p	Business Ns	Np	%p	Farmers Ns	Np	%p
Niger	50	3	1.4	70	3	1.1	30	1	0.9
Kwara	62	2	0.9	70	1	0.4	18	3	2.6
Nasarawa	60	-	-	69	1	0.4	21	1	0.9
FCT	50	3	1.4	54	4	1.5	46	5	4.4
Total	**222**	**8**	**3.7**	**263**	**9**	**3.4**	**115**	**10**	**8.8**

NS – Number screened , NP- Number positive, %p- percentage positive, FCT – Federal Capital Territory

Of the 295 stool samples collected from children that drink water from either tap or borehole, 3.8% were positive and distributed as follows: Niger 1.7%, Kwara 0.7%, none for Nasarawa and FCT 1.4% (Table 6). And out of the 305 stool samples collected from children that drink water from rivers and/or streams, 5.3% were found to be positive and distributed as follows: Niger 0.7%, Kwara 1.4%, Nasarawa 0.7%, and FCT 2.6% (Table 6).

Table 6: Distribution of rotavirus infection according to water sources

Location (State)	Water sources: Tap borehole Ns	Np	%p	Stream/river Ns	Np	%
Niger	68	5	1.7	82	2	0.7
Kwara	81	2	0.7	69	4	1.3
Nasarawa	74	-	-	76	2	0.7
FCT	72	4	1.4	78	8	2.6
Total	295	11	3.8	305	16	5.3

NS – Number screened , NP- Number positive, %p- percentage positive, FCT – Federal Capital Territory
FCT – Federal Capital Territory

Out of the 286 stool samples collected from children that use pit or flush latrine, 3.2% were positive for rotavirus antigens and distributed as follows: Niger state 0.7%, Kwara State 0.7%, none for Nasarawa State and FCT 1.8% (Table 7). Similarly, of the 314 stool samples collected from children without latrine, 5.7% were found positive and distributed as follows: Niger state 1.6%, Kwara state 1.3%, Nasarawa state 0.6% and FCT 2.2% (Table 7).

Table 7: Distribution of rotavirus infection according to latrine type

Location (State)	Latrine type: Pit/flush Ns	Np	%p	Open space Ns	Np	%p
Niger	70	2	0.7	80	5	1.6
Kwara	77	2	0.7	73	4	1.3
Nasarawa	59	-	-	91	2	0.6
FCT	80	5	1.8	70	7	2.2
Total	286	9	3.2	314	18	5.7

NS – Number screened , NP- Number positive, %p- percentage positive, FCT – Federal Capital Territory
FCT – Federal Capital Territory

DISCUSSION

Diarrheal disease is an important cause of morbidity and mortality in children and rotavirus has been identified as an important causative agent among children less than 5 years of age (Santos and Hoshino, 2005). Globally, infectious gastroenteritis has been ranked the second most common disease and accounts for 16 percent of all illnesses among infants and young children world wide (Armah *et al.*, 2003).

In Africa and other developing nations of the world the impact of diarrheal illnesses on infants and young children is staggering. An estimated number of diarrheal episodes in children younger than 5 years of age is about 450 million and 1 – 4 percent of this resulted in the deaths of children (Armah *et al.*, 2003).

Biological and Environmental Sciences Journal for the Tropics 9(1), March, 2012

ISSN 0794 – 9057

Recently, in sub-saharan Africa diarrheal diseases have been ranked first among infectious diseases in the categories of both frequency and mortality with the greatest burden on infants and young children. Gastroenteritis associated diseases is responsible for the death of over 33,000 children below 5 years of age among Nigerian children and rotavirus has been linked to the disease as reported by Aminu *et al.* (2008). Efforts to develop a candidate vaccine that would be suitable to Nigerian situation rely to a great extent on the identification of the strains of the rotaviruses and determination of possible genetic combinations of the virus in circulation in Nigeria.

In this study, rotavirus was detected in stool samples obtained from young children and infants with diarrhea who were presented in the hospitals located in the major towns and cities of the three North Central States of Nigeria and the FCT. The virus antigens detected in the stool samples were antigenically sub grouped and the genome profile analysed by reverse transcriptase polymerase chain reaction (RT – PCR) and agarose gel electrophoresis (AGE) techniques.

The present study conducted in 3 states and FCT reported an overall prevalence of 4.5%. Different results were reported with high prevalence ranging from 9% to 27% in previous studies conducted in Nigeria by Gomwalk *et al.* (1990); Gomwalk *et al.* (1993); Nimzing *et al.* (1998); Adah *et al.* (2001); Steele *et al.* (2002); Aminu *et al.* (2008); Odimayo *et al.* (2008); Aminu *et al.* (2009) and Dzikwi *et al.* (2009). Reasons to explain why the report of the present study indicated low prevalence of 4.5% compared to previous reports that indicated prevalence range of 9% to 27% could be attributed largely to ignorance about rotavirus gastroenteritis in the past. It could also be attributed to improvements recorded on the compliance with the provision of sanitary laws and standards being enforced by government mostly in the states capitals. Similarly present study reported rotavirus diversity in a wider geographic area of Nigeria and also evaluated socioeconomic and environmental factors as likely predisposing factors in rotavirus infection in the study areas compared to the previous reports that investigated cases of rotavirus gastroenteritis in a small geographic area and only considered limited number of socio-economic and environmental factors as likely predisposing factors in rotavirus infection. These explain why there were differences between the present study and the previous reports.

The prevalence of the virus infection among children in the rural areas and children from urban settlements were 5.6% and 3.6% respectively (Table 1). Reasons to account for the difference arising from the rate of infection associated with rotavirus between children from rural settings and their counterparts in urban settings could be attributed to lack of portable (treated) water, and poor hygienic environment as a result of indiscriminate disposal of both human and animal wastes. Furthermore, poor quality of food and inability to promptly visit hospitals for medication due to ignorance and/or poverty might be another reason. Although previous report by Glass *et al.* (2006) indicated that rotavirus infection was not associated with quality of environment, water and food, it is difficult to rule out the issue of water pollution and general lapses in hygienic practices peculiar to most rural communities in Africa, like Nigeria as a major contributing factor in diseases transmission particularly paediatric diarrhea (rotavirus infection). The fact that most rural settings in Nigeria and some other African countries such as Niger, Somalia and Ethopia have their sources of water from streams and rivers, coupled with the fact that the source of the water is shared with domestic animals, the frequent usage of the water without being treated increases the chances of transmission of diarrheal diseases among people especially the younger ones that are immunologically naive. However, the differences in the prevalence of rotavirus infection according to location (i.e rural or urban settlement) was not statistically significant (p- 0.028 and 0.085) i.e (p>0.005). This was previously reported by Hejkal *et al.* (1984); Pang *et al.* (2004); Santos and Hoshino (2005); Glass *et al.* (2006) and Mishra *et al .* (2010), who indicated that rotavirus infection was not related to the quality of water, food and environment of children.

The prevalence of rotavirus infection among children between the age group <1–2 years and 3 – 5 years were 5.9% and 3.4% respectively (Table 2). Although there seems to be a wide difference between the two figures above (5.9 % and 3.4%), there is no statistically significant difference between the two values (p = 0.043 and 0.134). The reasons to explain the difference in the values among children in the age groups <1-2 and 3-5 years cannot be far fetched, in the sense that the most affected age group of <1-2 years could be linked to the premature nature of the immune system of the children, although exclusive breast feeding has been reported to confer immunity on the infants (Armah *et al.*, 2003; Mishra *et al.,* 2010), the factor behind the high prevalence of infection with rotavirus among the children (<1-2 years) in the present study might further be attributed to the inability of the nursing mothers, particularly in rural settings to exclusively breast feed their babies as specified by UNICEF. In a similar study by Aminu *et al.* (2008) in North Western Nigeria, a high prevalence of rotavirus diarrhea was reported in younger children, and that report was corroborated by the present study. A prevalence of 5.9% rotavirus infection was found in children <1-2 years as against 3.4% in older children (3-5 years) (Table 2). On the contrary, age was found not to influence rotavirus infection in the study areas (p = 0.043 and 0.134).

The prevalence of rotavirus infection among male and female children screened was 3.7% and 5.5% respectively. The difference in the prevalence of the infection among the two groups was not statistically significant (Table 3). Sex was not found to be a significant factor in the prevalence of rotavirus infection among male and female children in the study areas (p>0.005). However, studies by Steele *et al.* (2002); Armah *et al.* (2003); Robert (2004) and Glass *et al.* (2006) have consistently indicated that male children regardless of the age group or social status, are twice likely to be infected than their female counterparts.

The present study indicated that female children were more susceptible to the infection with the virus. This differ from earlier reports by Steele *et al.* (2002); Armah *et al.* (2003); Robert (2004) and Glass *et al.* (2006). The paradigm shift in the present study raised the speculation that female children could also experience same rate of infection with rotavirus like their male counterparts if exposed to the same situation or condition.

The prevalence of rotavirus infection in the stool samples collected over the two seasons in the year of study was different being higher in the dry months of the year (November 2008 – March 2009) with 7.4%. On the contrary, the prevalence of rotavirus infection during the rainy season (May 2009 – September 2009) was 1.4% (Table 4). However there was no significant difference statistically between the prevalence of infection among children in both the dry and rainy seasons. The out come of the present study is contrary to previous reports by Paul and Erinle (1982); Gomwalk *et al.* (1993); Santos and Hoshino (2005); Rutjes *et al.* (2009) and Mishra *et al.* (2010) who reported that low humidity associated with dry season has significant influence in rotavirus infection among children. The overall prevalence of rotavirus infection in this study and previous studies conducted by Aminu *et al.* (2008); Aminu *et al.* (2009) is typical of countries in the tropics and subtropics like Nigeria.

The prevalence of infection among children of civil servants, business parents and farmers/low income earners was 3.7%, 3.4% and 8.8% respectively (Table 5). The rate of infection was higher among children of low income earners 8.8% compared to children of civil servants with 3.7% and those whose parents are into business with 3.4% (Table 5). The results of this study therefore showed that rotavirus gastroenteritis is associated with poverty, poor environmental standards, poor nutritional qualities peculiar with the poor. Although studies by Glass *et al.* (2006) and Mishra *et al.* (2010) have revealed that rotavirus infection in children is not influenced by socio economic status of the parents, it is convincing in this study that the disease is associated with the poor, because the total number of stool samples collected from the children of the low income earners 115 was far below the stool samples collected from the other two categories, i.e children of the civil servants 222 and those whose parents are into business 263. Yet, the prevalence of infection was higher among children of the low income earners, 8.8% (Table 5). In Nigeria, poor environmental standards, general lapses in hygienic practices and high rate of environmental pollution are characteristics of the poor and therefore could have been the factor behind the high prevalence of the infection among the children of the low income earners in the study areas. However, the result of the present study confirmed that socio economic status of the parents has no influence on rotavirus infection in the study areas (p=0.030, 0.018 and 0.028). Similar results were reported by Glass *et al.* (2006) and Mishra *et al.* (2010).

Transmission of rotavirus gastroenteritis from person to person occurs through polluted water. Rotaviruses are quite stable in an environment that is moisty and dirty and have been found in water samples at levels as high as 1-5 infectious particles/gallon of water as reported by U.S. Food and Drug Administration (2007). In a similar study by Rutjes *et al.* (2009), it was reported that rotavirus is a causative agent in several waterborne outbreaks of diarrhea in both developed and developing nations. In this study the prevalence of rotavirus gastroenteritis among children that drink tap or borehole water and those that drink water from streams or rivers varied considerably. A higher prevalence of 5.3% was found among children that drink water from streams or rivers, compared to those children that drink water from tap or borehole with 3.8% (Table 6). This is similar to the reports by U.S. Food and Drug Administration (2007) and Rutjes *et al.*(2009), despite the fact that the environment where the present research was conducted (Nigeria) cannot be equated to advanced nations like the U.S.A. and Netherlands in terms of sanitary standards and environmental management. The similarities of those reports and the present study was the fact that water was considered as possible predisposing factor in rotavirus infection and mode of transmission among children. However, despite the difference in the prevalence between children that drink water from tap or bore hole and stream or river (5.3% and 3.8% respectively), there was no relationship statistically between the source of water and rotavirus gastroenteritis in the study areas (p> 0.005).

The prevalence of rotavirus infection among children with good toilet facilities in their respective homes and those that lack toilet facilities were 3.2% and 5.7% respectively (Table 7). However there was no significant difference statistically in the prevalence of the infection between children with good toilet facilities and those without toilet facilities (p>0.005). In a similar study conducted by U.S. Food and Drug Administration (2007), it was established that because a person with rotavirus diarrhea often excretes large numbers of virus (108-1010 infectious particles/gram of feces), infection doses can readily be acquired through contaminated hands, objects or untensils, especially in an environment that is characterized by indiscriminate disposal of fecal materials. This could have been the reason for the high prevalence of infection among children with no toilet facilities 5.7% (Table 6).

But the factor (toilet facilities) was confirmed statistically not relevant in rotavirus infection among children in the study area of the 3 north central states of Nigeria and the FCT. The prevalence of rotavirus infection in each of the 3 states was: Niger 1.2%, Kwara 1.0%, Nasarawa 0.3% and FCT 2.0%. It is evident that the Federal Capital Territory (FCT) has the highest prevalence of infection compared to the remaining 3 states.

This is a confirmation of the earlier report (Glass *et al.*, 2006) that rotavirus infection may not be associated with quality of an environment, as similar incidence of infection was observed in both developed and developing countries of the world.

Biological and Environmental Sciences Journal for the Tropics 9(1), March, 2012 ISSN 0794 – 9057

Reason to account for the high prevalence of rotavirus gastroenteritis in FCT, despite improved sanitary conditions, good water quality and increased public health awareness could be due to heavily populated residents of the satellite towns who enjoyed little access to good water quality, poverty coupled with limited access to health care facilities. Despite the differences in the prevalence figures in the 3 states and FCT, there was no significance difference between them in the three states and Federal Capital Territory.

Acknowledgement
I thank Education Tax Fund (ETF), for funding the research. I am also grateful to the Center for Biotechnology Research and Training ABU Zaria for providing laboratory space and equipments for the research.

REFERENCES

Adah, M. I., Watle, A and Taniguchi, K. (2001). Molecular Epidemiology of Rotavirus in Nigeria. Detection of Unusual strains with G2P(6)n and G8P(1) specificities. *Journal of Clinical Microbiology.* 39. (1), 3969 – 3975.

Aminu, M., Ahmad, A. A., Umoh, J. U., Dewar, J., Esona, M. D. and Steele, A. D. (2008). Epidemiology of Rotavirus Infection in North Western. *Journal of Tropical Paediatrics.* 54. (5), 340 – 342.

Aminu, M., Esona, M. D., Geyer, A. and Steele, A.D. (2009). Epidemiology of rotavirus and astrovirus infections in children in Northwestern Nigeria. *Annals of African Medicine.* **7.**(4), 168 – 174.

Armah, G. E., Steele, A. D., Binka, F. N., Esona, N. D., Asmah, H. R., Anto, F., Brown, D., Green, J., Cutts, F. and Hall, A. (2003). Changing patterns of Rotavirus Genotype in Ghana: Emergence of Human Rotavirus G9 as a major cause of Diarrhoea in children. *Journal of Clinical Microbiology.* 41 .(6), 2317-2322.

Dennehy, C. and Penelope, H. (1990). Choice Reference Assay for the Detection of Rotavirus versus Enzyme Immunoassays. *Journal of Clinical Microbiology.* **28 .**(6),1280 – 1283.

Dennehy, P.H. (2008). Rotavirus vaccines: an overview. *Clinical microbiology Review.* **21.** (1), 198 – 208.

Dzikwi, A.A., Umoh, U.J., Gosham, L.T. , Ahmad, A.A., DeBeer,M. and Steele, A.D. (2009). Electrophoretypes and Subgroups of group A Rotavirus circulating Among Diarrhoeic Children in Kano. *Annals of African Medicine Society.* **8.** (2), 121-127.

Glass, R.I., Bresee, J.S., Jiang, B., Parashar, U.D., Yee, E. and Gentsch, J.R.(2006). Rotavirus and Rotavirus Vaccines. Hot topics in infection and Immunity in children. **5.** 45-54.

Gomwalk, N.E., Gosham, L.T. and Umoh, U.J. (1990). Rotavirus Gastroenteritis in Paediatrics Diarrhoea in Jos, Nigeria. *Journal of Tropical Paediatrics.* **36.** (2), 52-57.

Gomwalk, N. E., Umoh, U. J., Gosham, L. T. and Ahmad, A. A. (1993). Influence of climatic factors on Rotavirus infection among children with acute Gastroenteritis in Zaria, Northern Nigeria. *Journal of Tropical Pediatrics.* **39.** (5), 293 – 297.

Hejkal, W. T., Smith, M. E. and Gerba, C. P. (1984). Seasonal occurrence of Rotavirus in Sewage. **47.** (1), 585 – 590.

Mishra, V., Awasthi, S., Nag, V. L. and Tandon, R. (2010). Genomic diversity of group A rotavirus strains in patient aged 1 – 36 months admitted for acute watery diarrhea in northern India: a hospital based study. *Journal of Clinical Microbiology and Infectious Diseases.* **16.** (1), 45 – 50.

Nimzing, L., Peenze, I., Beer, M., Geyer, A., Angyo, I., Gomwalk, N.E. and Steele, A.D. (1998). Human Group C Rotaviruses Identified in Nigeria Children. *Pubmed.* **5.**(3-4), 133-135.

Odimayo, M. S., Olanrewaju, W. I., Omilabu, S. A. and Adegboro, B. (2008). Prevalence of Rotavirus induced Diarhoea among children under 5years in Ilorin, Nigeria. *Journal of Tropical Pediatrics.* **54.** (5),343 – 346.

Pang, X. L., Lee, B. B., Leblanc, N., Pereksaitis, J. K. and Yu, I. P. (2004). Increased detection of rotavirus using a real time reverse transcription polymerase chain reaction (RT – PCR) assay in stool specimens from children with diarrhea. *Journal of Medical Virology.* **72.** 496 – 501.

Paul, M.O. and Erinle, E.A.(1982). Influence of Humidity on Rotavirus Prevalence among Nigeria infants and young children with gastroenteritis. *Journal of Clinical Microbiology.* **15.** (2), 212-215.

Robert, R.F. (2004). Pathogenesis of Intestinal and Systemic Rotavirus Infection. *Journal of Virology.* **78.** (19), 10213 – 10220.

Rutjes, S. A., Lodder, W. J., Doctors van leeuwen, A., and de Rotta Husman, A. M. (2009).
Detection of infectious rotavirus in naturally contaminated source water for drinking water production. *Journal of Applied Microbiology.* **107.** 97 – 105.

Santos, N. and Hoshino, Y. (2005). Global distribution of rotavirus serotypes/genotypes and its Implication for the development and Implementation of an effective rotavirus vaccine. *Reviews in Medical Virology.* **15.**(1), 29 – 56.

Steele, A.D., Nimzing, L., Peenze, I.M.C., DeBeer, A., Geyer, Angyo, I. and Gomwalk, N.E. (2002). Circulation of the Novel G8 and G9 rotavirus strains in Nigeria in 1998 / 1999. *Journal of Medical Virology.* **67.** 608 – 612.

United States. Food and Drug Administration (2007). Rotavirus. Center for Food Safety and
Applied nutrition. Department of Health and Human Services.

Wikipedia (2008). The free online Encyclopedia . (5th ed.) New York.