

AFS2022039/23415

## **Prevalence of Enteric Adenovirus Among Diarrheic Children Less than Five Years in Children's Specialist Hospital, Ilorin, Kwara State, Nigeria**

Odebisi-Omokanye, M.B.\*<sup>1</sup>, Udeze, A.O.<sup>2</sup>, Akinfaye, O.D.<sup>1</sup>, Agbaje S.T.<sup>3</sup>

<sup>1</sup>Medical Microbiology Unit, Department of Microbiology, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria.

<sup>2</sup>Virology Unit, Department of Microbiology, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria.

<sup>3</sup>Department of Virology, College of Medicine, University of Ibadan, Ibadan, Nigeria.

\*Corresponding author Email: [odebisimutiat@yahoo.com](mailto:odebisimutiat@yahoo.com), Tel: +234 (0) 803 400 6111

(Received November 28, 2022; Accepted in revised form December 22, 2022)

**ABSTRACT:** Acute infective gastroenteritis is a major global health problem with children under 5 years of age being predominantly susceptible. Adenoviruses, mainly enteric adenoviruses (EAd) type 40 (Ad40) and type 41 (Ad41), have been implicated in causing acute and severe diarrhea in young children worldwide. This study was therefore conducted to elucidate the prevalence and epidemiological features of enteric adenovirus in children aged 0-5 years being managed for acute diarrhea in Children's Specialist Hospital Ilorin, Kwara State, Nigeria where there is little or no information on its prevalence. A total of one hundred and eighty-eight diarrheic stool samples were obtained and screened for the presence of adenoviruses using monoclonal antibody-based Enzyme Immuno Assay (EIA), (Cortez Diagnostics INC., USA). The results were statistically analysed (Chi-Square and P-value) using descriptive Cross Tab Pearson's Statistical Method. Adenovirus antigen was detected in 23.4% (44/188) of the diarrheic stool samples. Among the infected patients, children < 2 years old were more vulnerable to enteric adenovirus infection, with the peak infection occurring between 7-12 months of age (28.2% prevalence rate). Also, male children had a higher incidence rate of 13.8% while the female had an incident rate of 9.6%. There was a significant association between marital status ( $p=0.04$ ) and occupation ( $p=0.02$ ) of the parent or guardian of the children and adenovirus infection. The findings from this study suggest that adenoviruses are important etiologic agents of diarrhoea in children within Ilorin Metropolis, thus there is an urgent need for proper diagnosis of adenovirus among children with symptoms of diarrhoea.

**Keywords:** Prevalence, Adenovirus, Children, Diarrhoea, ELISA.

### **Introduction**

One of the most common infectious childhood diseases is acute gastroenteritis, in relation to morbidity it comes on second row after upper respiratory cause infections (Kajon *et al.*, 2010). Acute viral gastroenteritis has been reported to be a major health problem and continues to be a critical cause of morbidity and mortality in developing countries (Domínguez, 2009). Aetiology is variable depending on factors like age, demographics and season. Children less than 5 years of age are predominantly susceptible to diarrhoea with a global estimate of between 3.5 and 7 episodes during the first 2 years of life. The greatest burden has so far been recorded the developing countries owing to lack of safe drinking water, poor sanitation and bad sanitary habits (WHO, 2009). The determination of the aetiology is important for proper and prompt treatment (Mohammad *et al.*, 2013).

Adenoviruses belonging to the genus Mastadenovirus of the family Adenoviridae cause a variety of diseases and are prevalent worldwide. They are major causes of clinical infections including respiratory diseases, gastroenteritis, and conjunctivitis (Babalola *et al.*, 2015). Adenoviruses are increasingly recognized as agents of life-threatening infection in immunocompromised patients, particularly in human immunodeficiency virus positive individuals and allogeneic bone marrow transplant recipients often with very high mortality. There are 52 serotypes classified into six species, A-G (Walsh *et al.*, 2009), of which species F serotypes 40 and 41 primarily affect the gut, contributing 5%-20% of hospitalizations for childhood diarrhea (Girard *et al.*, 2006). The incidence of infection is nearly 3 times greater in developing countries than developed ones (Mohammad *et al.*, 2013).

The enteric Adenoviruses are a relatively unknown entity in gastroenteritis epidemiology in Africa with the exception of South Africa where their etiological importance in paediatric gastroenteritis has been established (Aminu *et al.*, 2007). However, prevalence of is poorly reported in Nigeria probably due to low or lack of specificity of commercially available EIA for all circulating adenovirus strains.

Previous study in Nigeria by Nimzing *et al.* (2000) indicated a prevalence of 3.8% among diarrheic children in Jos. Audu *et al.* (2002) in Lagos reported a prevalence of 3% and Babalola *et al.* (2015) in Ondo also reported a prevalence of 18% among diarrheic between the ages of 0 to 5 years. Although, the prevalence of adenovirus in Nigeria has been reported in few studies conducted has been disturbing and to consider the fact that it is not recognised as a serious public health challenge is disheartening. The Federal Government of Nigeria initiated the Expanded Program of Immunization in 1979 aimed at reducing disease burden from vaccine preventable diseases but Adenovirus was not enlisted among these diseases, largely owing to the fact that there is no vaccine available for the prevention of gastrointestinal adenovirus at the moment.

This study was therefore conducted to investigate the epidemiology of human enteric adenoviruses associated with diarrhoea in children aged 0-5 years old in Ilorin, Northcentral Nigeria.

This present study was aimed at detecting the presence of adenovirus using commercial Enzyme Linked ImmunoSorbent Assay (ELISA) and elucidating the prevalence of enteric adenovirus among diarrheic children under-5 years of age in Ilorin, Kwara State and Also to assess the risk factors implicated in the transmission of the virus among these children.

## **Materials and methods**

*Study design and area:* This study was a cross-sectional descriptive study, designed to detect and determine the prevalence of adenovirus gastroenteritis in children between 0 to 5 years of age. This research was carried out at Children's Specialist Hospital Ilorin, Kwara State, Nigeria, amongst children (both inpatients and outpatients) of age 0-5 years who presented with acute gastroenteritis.

*Inclusion and exclusion criteria:* Children under 5 years who presented with loose watery stool more than 2 times in a 24-hr. period, with or without vomiting, fever, dehydration, stool with mucus, and abdominal pain were included in the study.

Children above 5 years old and those who fit into the inclusion criteria but whose caregiver did not consent.

*Ethical considerations:* Ethical approval (Appendix 1) was granted by the Ethical Reviews Committee of Kwara State Ministry of Health before the commencement of this study. Informed consent was obtained from parents of the participating children before sample collection. Patient's anonymity was maintained, data generated were confidential, and used only for the purpose of this research.

*Collection of fecal specimens:* One hundred and eighty-eight (188) faecal specimens were collected from children between the ages of 0-5 years that were presented or admitted at the hospital for acute diarrhoeal illness. Faecal samples were collected within 1 to 3 days after the onset of diarrhea illness. The specimens were collected in clean, labeled, screw-capped tubes and transported immediately in ice-chest to the Department of Microbiology Laboratory University of Ilorin and stored in a -20°C refrigerator until need for assay. The socio-demographic information and clinical presentations of the children were obtained with the aid of a questionnaire.

*Sample processing:* The samples were thawed prior to addition into the stool processing diluent. 250µl of each fecal specimen was picked using a micropipette and dispensed into the diluent tube. The tube was recapped and shaken for two minutes to ensure good sample dispersion and extraction of the antigen.

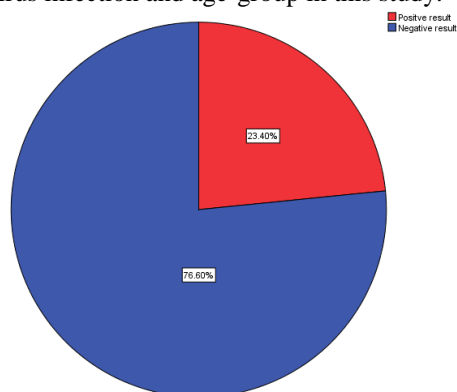
*Viral antigen detection using ELISA:* All the one hundred and eighty-eight (188) faecal specimens collected were analyzed for the presence of Adenovirus antigens using DAI Adenovirus Antigen Detection ELISA Kit (Diagnostic

Automation, Inc, USA) kits which have >99% sensitivity, and specificity respectively. Each of the tests was carried out according to the manufacturer's instructions.

*Statistical analysis:* Data obtained in the study was analyzed using descriptive statistics in percentages and ratios. Infection proportions were tested for statistical significance by the use of chi-square ( $\chi^2$ ) test and used to compare groups. Differences were considered statistically significant if  $P \leq 0.05$ . Also, Odd's Ratio with 95% Confidence Intervals were computed for the risk factors implicated in the transmission of Adenovirus.

## Results

A total of 188 diarrheic stool samples were screened for adenovirus antigen. Of these children that presented with diarrhoea, 23.4 % (44/188) were positive for adenovirus antigen (Figure 1). There was no significant association ( $p = 0.57$ ) between adenovirus infection and age-group in this study.



**Figure 1:** Prevalence of adenovirus iInfection in diarrhoeic children aged 0-5 years in Ilorin, Kwara State, Nigeria.

However, most of the positive cases of adenovirus gastroenteritis were under 2 years of age with highest prevalence in children 7-12 months of age (28.2%) and this was closely followed by children aged 0-6 months of age (25.0%), no positive case of adenovirus infection was found among the children above 2 years old (Table 1).

**Table 1:** Age Distribution of Adenovirus Infection among Children less than 5 years with Diarrhoea in Ilorin, Kwara State, Nigeria

Age (Months)	Positive (%)	Negative (%)	$\chi^2$ (P-value)
0-6	10 (25.0)	30 (75.0)	3.83 (0.57)
7-12	22 (28.2)	56 (71.8)	
13-18	8 (16.0)	42 (84.0)	
19-24	4 (25.0)	12 (75.0)	
25-36	0 (0.0)	2 (100)	
37-60	0 (0.0)	2 (100)	
<b>Total</b>	<b>44 (23.4)</b>	<b>144 (76.6)</b>	

Analysis of the result by gender among the children showed that adenovirus shedding occurred more frequently in females (24.3%: 18/74) than in males (22.8%: 26/114). However, the differences in the prevalence according to gender was not statistically significant ( $p = 0.81$ ) (Table 2).

**Table 2:** Distribution of Adenovirus Infection in Relation to Sex in Diarrheic Children 0-5 years old in Ilorin, Kwara State, Nigeria

Gender	Positive (%)	Negative (%)	$\chi^2$ (P-value)
Male	26 (22.8)	88 (77.2)	0.06 (0.81)
Female	18 (24.3)	56 (75.7)	
<b>Total</b>	<b>44 (23.4)</b>	<b>144 (76.6)</b>	

Among the possible risk factors examined, adenovirus infection was found to be significantly associated ( $p = 0.04$ ) with exclusive breastfeeding, it was however not associated ( $p > 0.05$ ) with socioeconomic status, source of drinking water, type of toilet, washing of hands before meal and washing of hands after toilet visitation (Table 3).

**Table 3:** Relationship between some possible risks factors studied and adenovirus infection in children aged 0-5 years in Ilorin, Kwara State, Nigeria

<b>Factor</b>	<b>Adenovirus Positive No.</b>	<b>Adenovirus Negative No.</b>	<b><math>\chi^2</math> (P-value)</b>
<b>Socio-economic status</b>			
High	15	39	0.80 (0.40)
Low	29	105	
<b>Fully Immunized</b>			
Yes	36	110	0.57 (0.45)
No	8	34	
<b>Exclusive breastfeeding</b>			
Yes	10	56	3.86 (0.04)
No	34	88	
<b>Source of drinking water</b>			
Well	20	26	2.52 (0.28)
Bore-hole	12	40	
Table water	6	46	
Pipe-borne water	6	32	
<b>Type of toilet</b>			
Pit-latrine	8	18	1.91 (0.59)
Water closet	32	104	
Open-field	4	22	
<b>Washing of hands before meal</b>			
Yes	12	98	3.45 (0.56)
No	32	46	
<b>Washing of hands after using the toilet</b>			
Yes	8	98	0.17 (0.68)
No	36	46	

With respect to sociodemographic characteristics of mother/guardian, 50% positivity was observed among children whose mothers are traders (8/16) and a statistical association was observed between occupation type ( $p = 0.02$ ) (Table 4).

**Table 4:** Prevalence of adenovirus distribution in relation to demographic characteristics of mother/guardian

<b>Variable</b>	<b>Adenovirus Positive No.</b>	<b>Adenovirus Negative No.</b>	<b><math>\chi^2</math> (P-value)</b>
<b>Marital Status</b>			
Single	0	10	0.80 (0.37)
Married	44	134	
<b>Type of marriage</b>			
Monogamy	2	108	
Polygamy	42	36	
<b>Educational level</b>			
Tertiary	22	82	0.57 (0.45)
Secondary	10	34	
Primary	12	22	
None	0	6	
<b>Occupation</b>			
Civil servant	12	38	3.86 (0.02)
Teacher	20	80	
Trading	8	8	
Full house wife	4	18	

In relation to some clinical signs, adenovirus was significantly associated with watery stool in this study ( $p = 0.01$ ). While no association was observed between other symptoms as fever, dehydration, cough, sunken eye, runny nose and conjunctivitis (Table 5).

**Table 5:** Clinical manifestations among diarrheic under-5 years children positive for enteric adenovirus in Ilorin, Kwara State, Nigeria

Signs/symptoms	N <sup>o</sup> positive adenovirus antigen (n=44)	$\chi^2$ (P-value)
Watery stool	22 (50.0)	53.19 (0.01)
Fever	17 (38.6)	0.09 (0.76)
Vomiting	22 (50.0)	0.42 (0.52)
Dehydration	40 (90.9)	0.15 (0.70)
Sunken eye	28 (63.6)	2.04 (0.15)
Cough	10 (22.7)	1.37 (0.24)
Runny nose	6 (13.6)	2.51 (0.11)
Conjunctivitis	22 (50.0)	0.95 (0.33)

Legend: Figures in parenthesis represent percentages.

## Discussion

In this study, a prevalence rate of 23.4% was recorded among children below five years who presented with diarrhoea at the Children's Specialist Hospital, Ilorin. This rate is significantly higher than the prevalence rate reported by Babalola *et al.* (2015) and Audu *et al.* (2002) wherein 18% and 16.7% prevalence rate were recorded respectively. The observed prevalence in this study is also slightly higher than the 22.3% previously reported by Aminu *et al.* (2007) in the North-western Nigeria. However, a similar prevalence (23%) was reported in Tanzania by Mhalu *et al.* (1988). Lower prevalence has been reported in other parts of Africa, Steel *et al.* (1990) reported 3% prevalence in South Africa, Moore *et al.* (1998), also reported 7.8% prevalence and Basu *et al.* (2003) reported 9.8% prevalence in Botswana. This difference in prevalence could be adduced to varying climatic factors, socioeconomic influence and environmental conditions. The prevalence rate recorded in this study further shows that enteric adenoviruses are becoming an important agent of infantile gastroenteritis in Northcentral Nigeria. This present prevalence value is however lower than the 48% reported by Al-Khafaji *et al.* (2014) which is probably due to the challenges of war and civil discord in Iraq, but much higher than the, 6.8% in Egypt (Zaghloul *et al.*, 2013), 3.6% in Brazil (Andreasi *et al.*, 2008), 2.9% in Iran (Savadkoobi *et al.*, 2007) and 1.5% in Argentina (Giordano *et al.*, 2001). Adenovirus infection was slightly higher prevalence was recorded among the female children than in the male children with no statistically significant difference ( $p = 0.81$ ). This observation is consistent with the findings of Audu *et al.* (2002); Aminu *et al.* (2007); Junaid *et al.* (2011) and Babalola *et al.* (2015). Result from this study further shows that gender does not play a role in adenovirus infection as there was no significant difference in the rate of infection between the males and females. The reason for the lack of significance difference in detection rate between male and female children may be that at younger age, both sexes have little or no major differences in their life style. Similar studies in other countries such as South Western Iran (Kajbaf *et al.*, 2013) and in Sudan (Magzoub *et al.*, 2013) have reported higher detection rates of enteric virus infection in male than in female children. However, a study from Cameroon have reported higher detection rates in female (45.3%) than in male children (40.8%) (Ndze *et al.*, 2012).

In this study, most of the children positive for adenovirus infection were under two years of age, stressing the fact that enteric viral infection occurs early in life. This finding is in consonance with a number of similar studies in Nigeria (Junaid *et al.*, 2011; Anochie *et al.*, 2013; Babalola *et al.*, 2015; Mukhtar *et al.*, 2015) and most parts of the world (Kargar *et al.*, 2012; Almusawi *et al.*, 2013; Magzoub *et al.*, 2013; Karakus *et al.*, 2014) where they reported higher prevalence of enteric viral infection mostly in children less than two years old. A breakdown of the children that were positive for adenovirus further shows that age groups 7-12 months had the highest prevalence of 28.2% followed by age groups 0-6 months, 19-24 months and 13-18 months each having a prevalence rate of 25%, 16% and 25% respectively. No positive case was recorded among those between 25 and 60 months of age. The result of this present research is in disagreement with the study conducted in North-western Nigeria, in which the highest incidence rate of 31% occurred in children in the age group 25-36 months old (Aminu *et al.*, 2007). It also differs

from the study conducted by Audu *et al.* (2002) in which the highest incidence rate of 28% occurred in children in the age group 13-24 months old (Audu *et al.*, 2002). However, it agrees with the study conducted by Babalola *et al.* (2015) in which the highest incidence rate occurred in the children in the age group 7-12 months. Reasons for the high prevalence rate recorded among children between the ages 7-12 months could be probably due to the waning of the prevailing maternal antibody, the introduction of varieties of weaning diets and drink, interaction with playgroups, teething where they tend to put almost anything their hands seem to find in their mouth and exposure to various environmental contaminants during the early walking and learning processes that may predispose the children to infection (Babalola *et al.*, 2015). As infection is more prevalent among children under two years of age, this age group may be the prime targets for vaccination.

In relation to some identified risk factors for enteric adenovirus infection, a statistically significant association was observed between with exclusive breastfeeding ( $p = 0.04$ ) and adenovirus infection. This indicated that breast feeding could offer some protection against enteric adenoviral infection. Breast milk has been reported by several researchers to confer some immunity on young children against series of childhood infections (Verhasselt, 2015).

The socio-economic status of the child's parent, type of toilet, previous history of diarrhea, mother's level of formal education was not significantly associated with rotavirus infection ( $p > 0.05$ ). These observations have been reported by studies carried out in other parts of the country (Pennap and Umoh 2010; Junaid *et al.*, 2011).

Out of the 22 children positive for adenovirus infection, 17 (77.3%) presented with fever while 5 (22.7%) had no to fever. This is slightly higher to the findings of Aminu *et al.* (2007) who recorded that 60% of infected children had fever. With respect to vomiting, 50% of the infected children were vomiting and this is also in consistent with the findings of Aminu *et al.* (2007) who also recorded 56% of the subjects were vomiting as at the time of recruitment into the study (Aminu *et al.*, 2007).

There is a significant relationship between marital statuses of parent, type of marriage of parent with risk of being infected. 22 of the children whose parent were married were infected while none of the children whose parent were single were infected. Of the 22 infected enrolee, 21 of the children who were infected was from a polygamous home and 1 was from a monogamous home. This high prevalence among subjects who live in a polygamous setting could be to the overcrowding and poor hygienic conditions which are usually common in polygamous family settings.

No significant relationship between immunization and risk of being infected. For children that were fully immunized, a higher number of them were those infected with enteric adenovirus. 18 of those that were immunized were infected, 4 of those not fully immunized were infected. This is clearly showing that the vaccination program does not cater for enteric adenovirus and as such the children population are not immune against the infection with enteric adenovirus (Tagbo *et al.*, 2019).

Distribution according to stool appearance indicates that infection of enteric adenovirus is often associated with the obvious symptoms of watery stool than mucoid or mucoid and bloody stool with a number of 17 (77.3%), 1 (4.5%) and 4 (18.2%) respectively. This slightly varies from Aminu *et al.*, (2007) in which 87.3% was recorded for watery stools, 19% mucoid stool and 3.2% in stool containing mucus and blood (Aminu *et al.*, 2007). Watery stool is also a symptom for many other infections, this is probably why cases of adenovirus are sparsely reported compared to other organisms causing acute gastroenteritis (CDC, 2019).

Finally, in the assessment of the Risk factors, this study shows that children whose parents uses pipe borne water and well water for them as sources of water are 3.1 and 1.6 times likely to be infected with adenovirus respectively. Children who have pit toilet as the type of toilet in their house are 1.6 times likely to be infected with adenovirus.

## **Conclusion**

Adenovirus is acute infectious disease that causes acute gastroenteritis. It is often a mild viral infection usually affects children of 0-5 years. It is considered a disease of public health importance because severe cases of enteric adenovirus infection can lead to death of children and it is not vaccine preventable yet. It is becoming evident from this present study that enteric adenoviruses are becoming an important agent of infantile gastroenteritis in North Central Nigeria. However, information on Adenovirus as an aetiological agent of gastroenteritis among Nigerian children is still very sparse.

Further studies are vital to determine the genotypes of the detected strains for molecular epidemiology which will be very useful in vaccine development.

## References

- Al-Khafaji ZA, Al-Mola GA, Youins A, AlKhafaji K: Detection of human torovirus like particles and adenovirus type F in children attending to Babylon Maternity and Children Hospital. *J Nat Sci Res*, 4(9):17-24. 2014.
- Al Musawi M, Zainaldeen H, Shafi F, Anis S, De-Antonio R: Rotavirus Gastroenteritis in Children under 5 years in the Kingdom of Bahrain: hospital- based surveillance. *J Clin Epidemiol*, 5:269-275. 2013.
- Aminu M, Ahmad AA, Umoh JU, de Beer MC, Esona MD, Steele AD: Adenovirus infection in children with diarrhoea disease in North-western Nigeria. *Ann Afr Med*, 6(4):168-173. 2007.
- Anochie PI, Onyeneke EC, Asowata EO, Afocha E, Onyeozirila AC, Ogu AC, Onyeneke BC: The role of rotavirus associated with gastroenteritis in a general hospital in Lagos, Nigeria. *Germes* 3(3):81-89. 2013.
- Andreasi MS, Cardoso DD, Fernandes SM, Tozetti IA, Borges AT, Fiaccadori FS, Santos RA, Souza M: Adenovirus, calicivirus and astrovirus detection in fecal samples of hospitalized children with acute gastroenteritis from Campo Grande, MS, Brazil. *Mem Inst Oswaldo Cruz*, 103(7):741-744. 2008.
- Audu R, Omilabu AS, Peenze I, Steele AD: Viral diarrhoea in young children in Nigeria. *Cent Afr J Med*, 48:59-63. 2002.
- Babalola MO, Odaibo GN, Olaleye DO, Alonge AO: Enteric Adenovirus and norovirus gastroenteritis among under-5 years children in Owo, Ondo State, Nigeria. *Br J Med Med Res*, 9(8): 1-9. 2015.
- Basu G, Rossouw J, Sebunya TK, Gashe BA, de Beer M, Dewar JB, Steele AD: Prevalence of rotavirus, adenovirus and astrovirus infection in young children with gastroenteritis in Gaborone, Botswana. *East Afr Med J*, 80(12):652-5. 2003.
- Centers for Disease Control and Prevention (CDC): Awareness on Adenovirus Infection. 2019.
- Domínguez A, Godoy P, Torner N, Cardeñosa N, Martínez A: The viral gastroenteritis: a public health problem. *Rev Esp Salud Publica*, 83(5):679-87. 2009.
- Giordano MO, Ferreyra LJ, Isa MB, Martinez LC, Yudowsky SI, Nates SV: The epidemiology of acute viral gastroenteritis in hospitalized children in Cordoba City, Argentina: An insight of disease burden. *Rev Inst Med Trop Sao Paulo*, 43(4):193-7. 2001.
- Girard MP, Steele D, Changnat CL, Kieny MP: A review of vaccine research and development: Human enteric infections, *Vaccine*, 24: 2732-2750. 2006.
- Junaid SA, Umeh C, Olabode A, Banda J: Incidence of rotavirus infection in children with gastroenteritis attending Jos University Teaching Hospital Nigeria. *Virol J*, 8, 233-241. 2011.
- Kajbaf TZ, Shamsizadeh A, Kalvandi G, Macvandi M: Relative frequency of rotavirus and adenovirus among children aged 1-60 months hospitalized with acute diarrhoea in South Western Iran. *Jundishapur J Microbiol*, 6:47-50. 2013.
- Kajon AE, Lu X, Erdman DD: Molecular epidemiology and brief history of emerging adenovirus 14-associated respiratory disease in the United States. *J Infect Dis*, 202(1):93-103. 2010.
- Karakus YT, Bircan S, Saime ED: Incidence of rotavirus and adenovirus 40/41 in children and infants. *Eur J Med Sci*, 1(1):22-25. 2014.
- Kargar M, Zare M, Najafi A: Molecular epidemiology of rotavirus strains circulating among children with gastroenteritis in Iran. *Iran J Pediatr*, 22:60-6. 2012.
- Magzoub MA, Bilal NE, Bilal JA, Osman OF: Rotavirus infection among Sudanese children younger than five years of age: a cross-sectional hospital-based study. *Pan Afr Med J*, 16: 88. 2013.
- Mhalu FS, Myrmel H, Msengi A, Haukenes G: Prevalence of infection with rotavirus and enteric adenoviruses among children in Tanzania. *NIPH Ann*, 11:3-7. 1988.
- Mohammad M, Amini E, Shirazi PT: Frequency of rotavirus and adenovirus gastroenteritis among children in Shiraz, Iran. *Iran Red Crescent Med J*, 15(8) 729-733. 2013.
- Moore P, Steele A, Lecatsas G, Alexander JJ: Characterization of gastroenteritis associated with adenoviruses in South Africa. *S Afr Med J*, 88:1578-1592. 1998.
- Mukhtar GL, Aminu M, Yakubu SE: Prevalence of adenovirus infection in children with diarrhoea in Katsina State, Northwestern Nigeria. *Katsina J Nat Appl Sci (KAJONAS)*, 4:131-137. 2015.
- Ndze VN, Akum AE, Kamga GH, Enjema LE, Esona MD, Banyai K, Therese OA: Epidemiology of rotavirus diarrhea in children under 5 years in Northern Cameroon. *Pan Afr Med J*, 11:73. 2012.
- Nimzing L., Geyer A, Sebata T: Epidemiology of adenovirus and rotavirus in young children in Jos, Nigeria. *South Afr J Epidemiol Infect*, 15:35-37. 2000.
- Pennap G, Umoh J: The prevalence of group A rotavirus infection and some risk factors in pediatric diarrhoea in Zaria, North Central Nigeria. *Afr J Microbiol Res*, 4(14):1532-1536. 2010.
- Savadkoobi RB, Ahmadpour-Kacho M, Yahyapour Y: Prevalence of viral gastroenteritis in children with acute gastroenteritis in Babol, Iran. *J Pediatr Infect Dis*, 2(4):211-4. 2007.
- Steele AD, Bos P, Lecatsas G: Adenovirus associated gastroenteritis at Ga-Rankuwa Hospital, South Africa. *South Afr J Epidemiol Infect*, 5:69-71. 1990.
- Tagbo B, Chukwubike C, Ezeugwu R, Ani E: Adenovirus and rotavirus associated diarrhoea in under 5 children from Enugu rural communities, South East Nigeria. *World J Vaccines*, 9:71-83. 2019.
- Verhasselt V: Is infant immunization by breastfeeding possible? *Philos Trans R Soc Lond B Biol Sci*, 370(1671):20140139. 2015.

- Walsh MP, Chintakuntlawar A, Robinson CM, Madisch I, Harrach B, Hudson NR, Schnurr D, Heim A, Chodosh J, Seto D, Jones MS: Evidence of molecular evolution driven by recombination events influencing tropism in a novel human adenovirus that causes epidemic keratoconjunctivitis. *PLoS One*, 3;4(6): e5635. 2009.
- World Health Organization (WHO). Viruses. In *Water Recreation and Disease. Plausibility of Associated Infections: Acute Effects, Sequelae and Mortality*; Pond, K., Ed.; IWA Publishing. 2009.
- Zaghloul MZ, El-Sahn SF, Galal ZA: Coinfection of rotavirus group A. Norovirus and adenovirus in Egyptian children with gastroenteritis. *Life Sci J*, 10(2): 848-852. 2013.