Prevalence, risk factors, and clinical characteristics of rotavirus and adenovirus among Lebanese hospitalized children with acute gastroenteritis

Rasha Zaraketa,2, Ali Salamib,2, Marwan Bahmada,3, Ali El Rozb,3, Batoul KHALAf, Ghassan Ghsseinb,c,**, Hisham F. Bahmad,d,*,1

a Faculty of Medicine, Beirut Arab University, Beirut, Lebanon
b Rammal Hassan Rammal Research Laboratory, Physio-toxicity (PhyTox) Research Group, Lebanese University, Faculty of Sciences (V), Nabatieh, Lebanon
c Department of Laboratory Sciences, Faculty of Nursing and Health Sciences, Islamic University of Lebanon, Khalde, Lebanon
d Department of Anatomy, Cell Biology, and Physiological Sciences, Faculty of Medicine, American University of Beirut, Beirut, Lebanon

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ABSTRACT

Background: Acute gastroenteritis is a very common infectious disease facing all age groups worldwide, especially the pediatric population. Viruses, bacteria, and parasites are all possible causes of infectious gastroenteritis; however, viruses have become more frequently identified with the advances in the ability to diagnose viral infections, particularly rotavirus and adenovirus. We aimed in our study to compare between the prevalence, risk factors, and clinical characteristics of rotavirus and adenovirus among children with viral gastroenteritis in Lebanon.

Materials and methods: A 12-months retrospective study was performed between January 1st and December 31st, 2018 including 308 children aged 1 month to 12 years, who were admitted to three tertiary healthcare centers in South Lebanon. Medical data were retrieved from patients’ files, including clinical and laboratory information.

Results: Rotavirus was found in stool of 204 patients (66.23 %), followed by adenovirus in 78 cases (25.32 %), and mixed group (rotavirus and adenovirus) in 26 cases (8.44%). The highest prevalence of rotavirus in our present study was seen among children between 12 and 23 months old, whereas patients infected with adenovirus were mainly aged between 24-35 months or 4–11 months. Majority of patients in the adenovirus and mixed groups had high-grade fever compared to the rotavirus group. Laboratory findings presented significantly higher average of white blood cells (WBCs), absolute neutrophil count (ANC), and C-reactive protein (CRP) in the mixed group compared to the two other groups. Monthly distribution of rotavirus and adenovirus infection revealed a biennial pattern of rotavirus incidence during January and July–August while frequency of adenovirus infection was highest during July–August.

Conclusion: Due to the high prevalence of viral diarrhea among the pediatric age group in our region, particularly rotavirus and adenovirus, along with the associated non-specific signs and symptoms, we highly recommend that medical laboratories be equipped for virus detection. Also, vaccination against rotavirus should be considered as a prevention strategy.

1. Introduction

Gastroenteritis is responsible for about 1.5 million doctor visits and 220,000 hospital admissions each year [2]. Although it can be caused by viral, parasitic, or bacterial enteropathogens, viruses remain the most common pathogens causing acute gastroenteritis among children below 5 years of age.
age [3]. Acute gastroenteritis is usually acquired by fecal-oral route, as well as through contaminated surfaces and from water sources [4, 5]. In the past, bacteria were thought to be the most common cause of gastroenteritis [6]; however, in the last two decades, viruses have become more frequently identified with the advances in the ability to diagnose viral infections [7]. Among the causative viruses, rotaviruses and adenoviruses represent the leading causative pathogens [8], along with other viruses such as noroviruses and astroviruses [9]. Symptoms of gastroenteritis vary between watery diarrhea, nausea, vomiting, fever, and abdominal pain, among others. These symptoms begin 1–2 days after contracting the infectious agent and may last from 3 up to 8 days in rotavirus [10]. Diarrhea, being the most common symptom, remains a major cause of childhood morbidity and mortality [11]. Reports state that more than 5 billion episodes of diarrhea occur in children below 5 years old of age causing about 2.5 million deaths annually, mainly in tropical regions [12].

The diagnosis of gastroenteritis is usually achieved by correlating the child’s symptoms and history of exposure. Although the majority of gastroenteritis cases are self-limiting, it remains a leading cause of morbidity and economic burden [13]. A major cause of childhood morbidity and mortality due to gastroenteritis worldwide is diarrhea. Gastroenteritis caused by bacteria are usually more severe and fatal, having high-grade fever and vomiting as common clinical presentation in most cases, while viral gastroenteritis is usually characterized by watery diarrhea and low-grade fever, along with vomiting and abdominal pain to a lesser extent. Additionally, tachycardia and tachypnea may be present due to fever and dehydration.

Among rotaviruses, the most common strains are G1P[8], G2P[4], G3P[8], G4P[8], and G9P[8] [14,15,16]. Each year, about 111 million episodes of gastroenteritis due to rotavirus are reported in children worldwide, of which 2 million require hospitalizations and 400,000 deaths occur [17], mostly in countries of Asia and Africa [18]. In Lebanon, prevalence of rotavirus has been reported to range between 27.7 and 30.6% [19, 20]. Moreover, a total of United States dollar (USD) 365 million is expended yearly to treat rotavirus gastroenteritis in China alone [21]. Therefore, the use of rotavirus vaccines in routine immunization programs worldwide is now highly recommended by The World Health Organization (WHO) [22].

As for adenoviruses, gastroenteritis is usually caused by group F strains, of which serotypes 40 and 41 are mainly detected in children [23]. Like rotavirus, adenovirus is spread via fecal-oral route causing diarrhea and fever among other symptoms. A strong association is also noted between adenovirus infection and intussusception [24], as well as increasing incidence of adenoviruses in children following bone marrow transplantation [25]. Since viral gastroenteritis has no definite therapy where symptomatic treatment is the mainstay in managing such cases, it is important to conduct local and regional epidemiological studies comparing between those two common viral infections among children. This is particularly essential for healthcare practitioners and officials to work on developing suitable vaccine programs and implement appropriate infection control measures [26].

Herein, we aimed at comparing between the prevalence, risk factors, and clinical characteristics of rotavirus and adenovirus among children with viral gastroenteritis. We conducted a 12-month study comprising virus testing of fecal specimens collected from hospitalized children under 12 years of age with acute diarrhea in 2018 in Lebanon.

2. Materials and methods

2.1. Study design and setting

During a one-year period, from January 1st, 2018 to December 31st, 2018, children were admitted to the pediatric department of three tertiary healthcare centers located in South Lebanon. Children aged from 1 month to 12 years old and hospitalized for acute gastroenteritis were retrospectively included in the study. We excluded patients with chronic diarrhea, malnutrition, immunodeficiency, or patients with multiple malformations. We also excluded all the non-Lebanese patients.

2.2. Ethical considerations

The experimental protocols followed in our retrospective study were performed in accordance with guidelines and regulations of The Code of Ethics of the World Medical Association (Declaration of Helsinki). The Institutional Review Board (IRB) approval of the Lebanese University (LU) and the Ethics Committee of the healthcare centers were obtained prior to commencement of the study. Written informed consents were obtained from the patients’ care givers before random recruitment of the included subjects.

2.3. Clinical variables and specimen collection

Medical data were retrieved from medical files of patients, including clinical and laboratory information following the patients from the admission until discharge. The following data were collected retrospectively:

- Patient demographics: data including the age, sex, family size, breast feeding, and the vaccination history to determine if any dose of Rotavirus vaccines were given.
- Clinical data: this category includes investigation for the presence of fever, vomiting (including its frequency per day and period in days), diarrhea (including its frequency and period in days), dehydration, flu-like signs/symptoms, nausea, abdominal pain, stool texture, antibiotic use prior to hospitalization, and the calculation of the index of severity “Vesikari Score System” [27].
- Laboratory test values: including results of stool analysis, quick identification tests for Adenovirus (CerTest; Biotec, Zaragoza, Spain) and Rotavirus (CerTest), in addition to blood levels of white blood cells (WBCs), hemoglobin (HGB), hematocrit (HCT), absolute neutrophil count (ANC), blood sugar (BS), and C-reactive protein (CRP).

2.4. Viral detection

Fresh stool samples from patients were acquired and analyzed. Samples were received by the laboratory of each tertiary healthcare center and tested within less than 1 h to check for the presence of infectious agents as previously described by our group [28]. Rotavirus and Adenovirus kit tests (CerTest; Biotec, Zaragoza, Spain) were used for viral detection [29] as validated previously [30]. Testing for both viruses was carried out according to the manufacturers’ instructions.

2.5. Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA). The level of significance was set at $p < 0.05$ for all statistical analyses. Descriptive analyses were based on frequencies and percentages. The demographic, clinical, and laboratory characteristics among the three study groups (rotavirus, adenovirus, and mixed) were tabulated. Baseline comparisons between groups were performed using Kruskall-Wallis test for continuous variables. The chi-square test was used to assess any significant difference between the categorical variables. Normality was tested using Kolmogorov-Smirnov test.

3. Results

3.1. Socio-demographic and clinical characteristics of patients

During the period between January and December 2018, out of 1,200 Lebanese children admitted to the three healthcare centers with a
diagnosis of acute gastroenteritis (AGE), 308 (25.7%) were diagnosed having rotavirus and/or enteric adenovirus infections. Among those, 135 (43.8%) were females and 173 (56.2%) were males. Patients were divided into seven age groups between 1 month and 12 years (1–3, 4–11, 12–23, 24–35, 36–47, 48–59 and ≥60) as previously described [1, 19]. The mean family size of patients was 4.21; 61.3% of patients were breastfed; and 35.6% of patients have been previously vaccinated with rotavirus vaccine (Table 1).

Rotavirus was found in stool of 204 patients (66.23%), followed by adenovirus in 78 cases (25.32%), and mixed group (rotavirus and adenovirus) in 26 cases (8.44%) (Figure 1). Our results showed a significant difference between patients among the three study groups (rotavirus, adenovirus, and mixed) with respect to their age categories (Table 1). Indeed, distribution of age revealed that majority of patients infected with rotavirus are aged between 12-23 months (31.2%), whereas patients infected with adenovirus were mainly aged between 24-35 months (27.3%) or 4–11 months (26.0%), and those co-infected with both viruses were mainly aged between 4-11 months (46.2%). Henceforth, distribution of age categories among the three patient groups was highly remarkable in children aged between 4 and 35 months (P < 0.001) (Table 1). For instance, majority of patients infected with rotavirus (76.1%) or co-infected with rotavirus/adenovirus (57.7%) have not previously taken the rotavirus vaccine (Table 1).

Table 1. Socio-demographic characteristics of 308 pediatric patients enrolled in the study.

| Demographics       | Rotavirus n (%) | Adenovirus n (%) | Mixed n (%) | Total GE N | P-value |
|--------------------|-----------------|------------------|-------------|------------|---------|
| Age (months)*      |                 |                  |             |            |         |
| 1-3                | 14 (6.9%)       | 2 (2.0%)         | 0 (0.0)     | 16         | 0.008   |
| 4-11               | 41 (20.3%)      | 20 (26.0%)       | 12 (46.2)   | 73         |         |
| 12-23              | 62 (31.2%)      | 18 (23.3%)       | 5 (19.2)    | 86         |         |
| 24-35              | 34 (16.8%)      | 21 (27.3%)       | 1 (3.9)     | 56         |         |
| 36-47              | 25 (12.4%)      | 11 (14.3%)       | 2 (7.7)     | 38         |         |
| 48-59              | 6 (3.0%)        | 2 (2.6%)         | 3 (11.5)    | 11         |         |
| ≥60                | 19 (9.4%)       | 3 (3.9%)         | 3 (11.5)    | 25         |         |
| Total N (%)        | 202 (100.0%)    | 77 (100.0%)      | 26 (100.0%) | 305        |         |
| Gender             |                 |                  |             |            |         |
| Female             | 88 (43.1%)      | 38 (48.7%)       | 9 (34.6%)   | 135        | 0.429   |
| Male               | 116 (56.9%)     | 40 (51.3%)       | 17 (65.4%)  | 173        |         |
| Total N (%)        | 204 (100.0%)    | 78 (100.0%)      | 26 (100.0%) | 308        |         |
| Breast feeding†    |                 |                  |             |            |         |
| No                 | 62 (35.2%)      | 29 (43.3%)       | 13 (50.0%)  | 104        | 0.126   |
| Yes                | 114 (64.8%)     | 38 (56.7%)       | 13 (50.0%)  | 165        |         |
| Total N (%)        | 176 (100.0%)    | 67 (100.0%)      | 26 (100.0%) | 269        |         |
| Rota-vaccine§      |                 |                  |             |            |         |
| No                 | 140 (76.1%)     | 24 (35.3%)       | 15 (57.7%)  | 179        | <0.001  |
| Yes                | 44 (23.9%)      | 44 (64.7%)       | 11 (42.3%)  | 99         |         |
| Total N (%)        | 184 (100.0%)    | 68 (100.0%)      | 26 (100.0%) | 278        |         |
| Mean family size   | 4.33            | 3.92             | 4.23        | 4.21       | 0.293   |

* Missing data. Significant p-values are made in bold.
other months, whereas adenovirus had prominent peaks in July and August, compared to other months (Figure 3).

4. Discussion

In our study, out of 1200 hospitalized Lebanese children suffering from AGE, 25.7% were diagnosed having rotavirus and/or enteric adenovirus infections. This is close to a 5-year study by Liu et al. where rotavirus and adenovirus were detected in 22.0% and 10.3% of cases, respectively. As noted in almost all studies, rotavirus is always more prevalent than adenovirus. This is true in our study as well with around two thirds of cases diagnosed with rotavirus alone (66%), followed by adenovirus in 25% of cases and mixed rotavirus and adenovirus co-infection in 9% of patients. In a 1-year study by Vesikari et al., rotavirus was found to be present in half of the cases while adenovirus was diagnosed in 11% of patients [31]. As for age group distribution, the highest prevalence of rotavirus in our present study was seen among children between 12 and 23 months old, which is similar to several reports demonstrating high rate of infection between 1 and 2 years of age [32, 33, 34, 35]. Indeed, incidence of rotavirus is greatest during the first 2 years of life [35, 36, 37]. In our study, a small number of patients were reported to have rotavirus infection at the age of 5 years or more. However, it is rarely reported since children have already acquired a natural immunity at this stage of life [38]. For adenovirus, patients were mainly aged between 24-35 months or 4–11 months.

In this study, monthly distribution analysis of rotavirus and adenovirus incidence revealed differential allocation in certain months, where rotavirus alone was highest in January while either of both viruses were found to be highest during July–August. This biennial pattern exhibited in rotavirus epidemiology is consistent with previous studies [39, 40]. Similarly, adenovirus infection being mostly incidental during the months of July and August specifically (wherein the weather is usually
Table 2. Clinical characteristics of 308 pediatric patients enrolled in the study.

| Clinical characteristics | Rotavirus n (%) | Adenovirus n (%) | Mixed n (%) | Total GE | P-value |
|--------------------------|-----------------|------------------|-------------|----------|---------|
| Stool texture            |                 |                  |             |          |         |
| Mucoidal                 | 14 (10.7%)      | 9 (18.4%)        | 7 (41.2%)   | 30       | 0.053   |
| Watery                   | 111 (84.7%)     | 39 (79.6%)       | 10 (58.8%)  | 160      |         |
| Bloody                   | 6 (4.6%)        | 1 (2.0%)         | 0 (0.0)     | 7        |         |
| Total N (%)              | 131 (100.0%)    | 49 (100.0%)      | 17 (100.0%) | 197      |         |
| Fever                    |                 |                  |             |          |         |
| Low-grade fever          | 27 (65.9%)      | 4 (40.0%)        | 0 (0.0%)    | 31       | 0.003   |
| High-grade fever         | 14 (34.1%)      | 6 (60.0%)        | 4 (100.0%)  | 24       |         |
| Total N (%)              | 41 (100.0%)     | 10 (100.0%)      | 4 (100.0%)  | 55       |         |
| Abdominal pain           |                 |                  |             |          |         |
| No                       | 15 (27.8%)      | 4 (50.0%)        | 1 (25.0%)   | 20       | 0.430   |
| Yes                      | 39 (72.2%)      | 4 (50.0%)        | 3 (75.0%)   | 46       |         |
| Total N (%)              | 54 (100.0%)     | 8 (100.0%)       | 4 (100.0%)  | 66       |         |
| Diarrhea                 |                 |                  |             |          |         |
| No                       | 20 (9.9%)       | 6 (7.8%)         | 5 (19.2%)   | 31       | 0.464   |
| Yes                      | 183 (90.1%)     | 71 (92.2%)       | 21 (80.8%)  | 275      |         |
| Total N (%)              | 203 (100.0%)    | 77 (100.0%)      | 26 (100.0%) | 306      |         |
| Diarrhea episodes per day|                 |                  |             |          |         |
| 1-3                      | 14 (34.2%)      | 4 (40.0%)        | 0 (0.0%)    | 18       | 0.620   |
| 4-5                      | 26 (63.4%)      | 6 (60.0%)        | 4 (100.0%)  | 36       |         |
| ≥6                       | 1 (2.4%)        | 0 (0.0)          | 0 (0.0%)    | 1        |         |
| Total N (%)              | 41 (100.0%)     | 10 (100.0%)      | 4 (100.0%)  | 55       |         |
| Diarrhea duration (days) |                 |                  |             |          |         |
| 1-4                      | 37 (94.9%)      | 8 (88.9%)        | 4 (100.0%)  | 49       | 0.688   |
| ≥5                       | 2 (5.1%)        | 1 (11.1%)        | 0 (0.0%)    | 3        |         |
| Total N (%)              | 39 (100.0%)     | 9 (100.0%)       | 4 (100.0%)  | 52       |         |
| Nausea                   |                 |                  |             |          |         |
| No                       | 22 (66.7%)      | 5 (62.5%)        | 4 (100.0%)  | 31       | 0.362   |
| Yes                      | 11 (33.3%)      | 3 (37.5%)        | 0 (0.0%)    | 14       |         |
| Total N (%)              | 33 (100.0%)     | 8 (100.0%)       | 4 (100.0%)  | 45       |         |
| Vomiting                 |                 |                  |             |          |         |
| No                       | 60 (29.6%)      | 29 (37.7%)       | 4 (15.4%)   | 93       | 0.240   |
| Yes                      | 143 (70.4%)     | 48 (62.3%)       | 22 (84.6%)  | 213      |         |
| Total N (%)              | 203 (100.0%)    | 77 (100.0%)      | 26 (100.0%) | 306      |         |
| Vomiting episodes per day|                 |                  |             |          |         |
| 0                        | 8 (19.5%)       | 4 (40.0%)        | 0 (0.0%)    | 12       | 0.153   |
| 1                        | 14 (34.2%)      | 1 (10.0%)        | 3 (75.0%)   | 18       |         |
| 2-4                      | 19 (46.3%)      | 5 (50.0%)        | 1 (25.0%)   | 25       |         |
| Total N (%)              | 41 (100.0%)     | 10 (100.0%)      | 4 (100.0%)  | 55       |         |
| Vomiting duration (days) |                 |                  |             |          |         |
| 0                        | 8 (21.0%)       | 4 (40.0%)        | 0 (0.0%)    | 12       | 0.308   |
| 1                        | 25 (65.8%)      | 6 (60.0%)        | 4 (100.0%)  | 35       |         |
| 2                        | 5 (13.2%)       | 0 (0.0%)         | 0 (0.0%)    | 5        |         |
| Total N (%)              | 38 (100.0%)     | 10 (100.0%)      | 4 (100.0%)  | 52       |         |
| Dehydration              |                 |                  |             |          |         |
| No                       | 74 (51.7%)      | 33 (54.1%)       | 9 (47.4%)   | 116      | 0.709   |
| Yes                      | 69 (48.3%)      | 28 (45.9%)       | 10 (52.6%)  | 107      |         |
| Total N (%)              | 143 (100.0%)    | 61 (100.0%)      | 19 (100.0%) | 223      |         |
| Flu-like signs/symptoms  |                 |                  |             |          |         |
| No                       | 26 (56.5%)      | 5 (100.0%)       | 0 (0.0%)    | 31       | 0.009   |
| Yes                      | 20 (43.5%)      | 0 (0.0%)         | 4 (100.0%)  | 24       |         |
| Total N (%)              | 46 (100.0%)     | 5 (100.0%)       | 4 (100.0%)  | 55       |         |
| Antibiotic prior to hospitalization | | | | | |
| No                       | 101 (71.6%)     | 39 (76.5%)       | 16 (84.2%)  | 156      | 0.680   |
| Yes                      | 40 (28.4%)      | 12 (23.5%)       | 3 (15.8%)   | 55       |         |
| Total N (%)              | 141 (100.0%)    | 51 (100.0%)      | 19 (100.0%) | 211      |         |

* Missing data. Significant p-values are made in bold.
hot due to Summer in Lebanon) has been reported in world literature in previous studies as well [41]. This variability might be owing to weather conditions which affect transmission of the viruses more rapidly.

With respect to the associated laboratory findings, significantly higher average of WBC, ANC and CRP were detected among patients co-infected with both rotavirus and adenovirus rather than those in the two other groups alone. In our study, mean CRP level in the rotavirus group of patients was found to be 22 mg/L, which is in consistent with a study by Lausch et al. were rotavirus patients had significantly lower CRP level (below 50 mg/L) with non-rotavirus patients [42]. Interestingly, co-infection with both viruses among our patients was associated with a mean CRP of 158 mg/L which is most likely due to severe inflammation accompanying both viruses. A possible explanation of the low CRP levels among patients infected with rotavirus might be the immunosuppressed state accompanying those patients as shown in a study by Lausch et al. [42].

Rotavirus, being the most common viral cause of gastroenteritis, is associated with frequent hospitalizations and deaths among children worldwide, and large annual costs for treatment have been reported in many countries [43]. The severity of rotaviruses is seen among babies younger than 11 months old, with the highest mortality rate seen in Africa, Latin America, and Asia, with an estimation of 6% overall mortality among children below 5 years old [44]. With advancement in the medical field, two orally-administered rotavirus vaccines had been licensed and are available worldwide since 2006 [45]. In our study, a significant association was detected between infection with rotavirus and adenovirus on one hand and rotavirus vaccination status on the other side. In fact, patients who previously received the vaccine are less prone to contract rotavirus alone or co-infection with both viruses as shown with a smaller number of patients in those two groups who got the vaccine shot than in those who did not. Nowadays, the wide availability of rotavirus vaccination for children in almost all countries is extremely important and is highly recommended by physicians [46].

We believe our manuscript has several limitations. First, we acknowledge that one-year surveillance data might not be enough to compare between the prevalence, risk factors, and clinical characteristics of rotavirus and adenovirus infections in Lebanon. However, results obtained from our study pave the way for conducting subsequent studies on larger cohorts of patients. Second, some data might have been missing from the medical records of the patients, including details about breastfeeding, rotavirus vaccination, and others.

| Clinical Characteristics | Rotavirus | Adenovirus | Mixed | Total | P-value |
|--------------------------|-----------|------------|-------|-------|---------|
| Frequency (%)            | 204 (66.2%) | 78 (25.3%) | 26 (8.5%) | 308 (100.0%) | -       |
| Clinical manifestations  |           |            |       |       |         |
| Vesikari score (Mean ± SD) | 10.95 ± 1.77 | 10.85 ± 2.10 | 11.58 ± 1.54 | 10.97 ± 2.12 | 0.431   |
| Duration of hospitalization per days (Mean ± SD) | 3.46 ± 1.53 | 3.28 ± 1.57 | 3.40 ± 1.08 | 3.01 ± 1.53 | 0.470   |
| Laboratory findings      |           |            |       |       |         |
| WBCs (∗10³ per mm³)      | 9.03 ± 3.09 | 10.34 ± 3.54 | 13.19 ± 3.82 | 11.54 ± 5.00 | 0.017   |
| ANC (∗10³ per mm³)       | 53.85 ± 14.94 | 43.05 ± 22.67 | 70.00 ± 19.79 | 53.16 ± 40.93 | 0.018   |
| HGB (g/dL; mean ± SD)    | 11.02 ± 0.99 | 11.96 ± 1.11 | 11.18 ± 0.41 | 11.86 ± 5.08 | 0.319   |
| HCT (in %; mean ± SD)    | 32.38 ± 2.67 | 34.27 ± 5.05 | 33.54 ± 1.62 | 33.82 ± 3.81 | 0.861   |
| BS (in mg/dL; mean ± SD) | 76.68 ± 24.78 | 82.25 ± 17.25 | 107.20 ± 18.44 | 88.88 ± 24.67 | 0.074   |
| CRP (in mg/L; mean ± SD) | 22.10 ± 24.84 | 19.37 ± 54.75 | 158.72 ± 207.39 | 42.96 ± 59.59 | 0.001   |

Abbreviations: ANC: absolute neutrophil count; BS: blood sugar; CRP: C-reactive protein; HCT: hematocrit; HGB: hemoglobin; WBCs: white blood cells. Significant p-values are made in bold.
5. Conclusions

In conclusion, our results indicate that rotavirus infection is much more frequent (66.23%) than adenovirus infection (25.32%) among Lebanese children, with the majority of patients contracting both viruses between 4 and 35 months of age. The larger portion of patients infected with rotavirus (76.1%) or co-infected with rotavirus/adenovirus (57.7%) were found not to be previously vaccinated against rotavirus, which reflects the importance of implementing vaccination programs to raise public awareness on the importance of vaccination in South Lebanon. Such campaigns need to be implemented during periods of the year where viral infections mostly occur. In our study, monthly distribution analysis revealed biennial pattern of rotavirus infection (during January and July–August months) among Lebanese children whereas adenovirus infection mainly occurred during the months of July–August only. Also, it is highly recommended to improve the laboratory detection of gastroenteric viruses using specific viral panels. More specifically, rotavirus and adenovirus antigens should be investigated on a routine basis in fresh stool samples to reach an accurate diagnosis and treatment of gastroenteritis among children.

Declarations

Author contribution statement

R. Zaraket, A. Salami and G. Ghsein: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. M. Bahmad and A. Al Rozi: Analyzed and interpreted the data; Wrote the paper. B. Khalaf: Performed the experiments; Analyzed and interpreted the data. H. Bahmad: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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