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Prevalence and Epidemiological Characteristics of Rhinovirus Infections in Young Children in Côte d'Ivoire, 2022-2023

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Abstract

Background: Rhinoviruses (HRV) are among the leading viral agents of acute respiratory infections (ARIs) in young children, particularly in low- and middle-income countries. However, data on their epidemiology in Côte d'Ivoire remain limited. This study aims to describe the prevalence, epidemiological profile, and seasonal patterns of HRV infections among children under five years of age from 2022 to 2023. **Methods:** This retrospective descriptive study analyzed 4480 nasopharyngeal specimens collected through the national influenza and respiratory virus surveillance network. Children presenting with Influenza-Like Illness (ILI) or Severe Acute Respiratory Infection (SARI) were tested by RT-qPCR. Demographic, clinical, and climatic data were statistically assessed to identify factors associated with HRV infection. **Results:** HRV prevalence was 4.1% (182/4480), with a significant increase between 2022 (3.3%) and 2023 (4.7%; $p < 0.021$). Most infections occurred in infants aged 0 - 12 months (67.6%). No significant association was found with sex or clinical severity (ILI vs. SARI). Fever was significantly more common among HRV-positive children ($p < 0.001$), while gastrointestinal symptoms were less frequent. HRV circulation exhibited clear seasonality, with peaks during months of high

humidity and rainfall. Rainfall showed a significant positive correlation with HRV incidence ($r = 0.58$; $p < 0.05$). **Conclusion:** HRV is an important contributor to respiratory infections in Ivorian children, particularly infants. Its seasonal dynamics are strongly influenced by local climatic conditions. These findings underscore the need to strengthen surveillance and integrate climate indicators into ARI prevention strategies in tropical regions.

Keywords

Rhinovirus, Côte d'Ivoire, Acute Respiratory Infections, Children under Five, RT-qPCR, Seasonality, Epidemiology

1. Introduction

Acute respiratory infections (ARIs) are among the leading causes of morbidity and mortality in children under five years of age, particularly in low- and middle-income countries [1]. Among the etiological agents of ARIs, rhinoviruses (RVs) play an important role as frequently implicated pathogens [2]. Although typically mild, these viruses can lead to severe complications, especially in young children or those with comorbidities [3]. According to the World Health Organization (WHO), each child develops on average about 6 to 8 episodes of ARI during the first five years of life representing approximately 238 million cases and nearly 13 million deaths annually, of which 50% occur in sub-Saharan Africa making ARIs a major public health concern [4]. However, heterogeneity in diagnostic methods and the scarcity of longitudinal studies hinder the establishment of a comprehensive understanding of their true impact. In addition, socio-environmental determinants such as population density, access to healthcare, and living conditions significantly influence the transmission and severity of viral respiratory infections in children [5]. Côte d'Ivoire, like other sub-Saharan African countries, is not spared from ARIs. Studies by Benié *et al.* (2019) [6] show that acute respiratory infections are the second leading cause of pediatric consultations. Nevertheless, available data on the contribution of rhinoviruses among young children remain almost nonexistent. Yet, studying rhinoviruses is particularly important in a context marked by increased pressure on healthcare infrastructure due to the high number of consultations for respiratory infections in early childhood. Between 2022 and 2023, active surveillance of respiratory infections was conducted, providing a unique opportunity to assess the epidemiological dynamics of rhinovirus infections in this vulnerable age group. This two-year period was selected because it corresponds to a post-pandemic phase during which activities progressively resumed, surveillance systems stabilized, and the quality and reliability of the data significantly improved. The aim of this study is therefore to describe the prevalence, epidemiological characteristics, and factors associated with rhinovirus infections among children under five years of age in Côte d'Ivoire over a two-year period, as well as to contribute to a better understanding of the seasonal patterns of rhinoviruses.

2. Material and Methods

2.1. Study Design and Setting

This was a retrospective descriptive study based on data collected through the national surveillance network for influenza and other respiratory viruses.

2.2. Respiratory Viruses' Surveillance System

The respiratory virus surveillance system is coordinated by the National Institute of Public Hygiene (INHP) and the National Influenza Center (NIC), which oversees the national program for influenza and other respiratory viruses. The surveillance system network consists of 10 sentinel healthcare facilities selected based on their geographic location, patient attendance capacity, availability of trained voluntary staff, and ability to provide complete and reliable epidemiological data. Respiratory specimen collected were analyzed at the NIC at the Pasteur Institute of Cote d'Ivoire (IPCI).

2.3. Study Population

The study population included children aged ≤ 5 years who presented with Influenza-Like-Illness (ILI) or Severe Acute Respiratory Infection (SARI) according to WHO case definition [7] at the sentinel sites between January 2022 and December 2023. According to the WHO, a case of Influenza-Like Illness (ILI) is defined as an acute respiratory infection with a measured fever of 38 ˚C or higher and a cough, with symptom onset within the past ten days. In contrast, a Severe Acute Respiratory Infection (SARI) is an acute respiratory infection presenting with fever (or a history of fever) and cough, with symptoms starting within the past ten days and severe enough to require hospitalization.

2.4. Samples Collection and Transportation

Nasopharyngeal swabs were collected by trained healthcare workers using standard operating procedures [8]. Collected samples were placed in universal viral transport medium (UTM) [9].

Samples were transported by postal service within a maximum of 72 hours from the health center to the NIC under control cold-chain. Each shipment is accompanied by epidemiological information forms including sociodemographic characteristics (age, sex, sentinel site, date of notification), clinical manifestations (fever, cough, diarrhea, vomiting). Comorbidities such as chronic lung disease, obesity, asthma, and immune disorders were also recorded.

2.5. Laboratory Testing

Viral RNA extraction was performed from respiratory specimens using the Qi-Aamp Viral RNA Mini kit (Qiagen, Hilden Germany) according to the manufacturer's instruction. Final elution of the genetic material was carried out in 60 µl of RNAse free water. Rhinovirus detection was conducted by real-time RT-PCR targeting the 5'-UTR region of the viral genome, using the primers and probe de-

scribe by linsuwanon *et al.* (2009): Forward 5'-AGTCCTCCGGCCCCTGAAT-3', Reverse 5'-ACACGGACACCCAAAGTAGT-3', and the probe (CY5)-TGAG-CAATTGTGGATGGGA-(BHQ-2) [10].

The reaction mixture (Master-mix) was prepared on ice in a final volume of 25 µl containing 12.5 µl of 2X buffer, 7.5 µl of Rnase free water, 1 µl of $MgSO_4$, 0.5 µl of probe (10 pM), 1 µl of primers (10 pM), and 2.5 µl of extracted viral RNA. Amplification reactions were performed using QuantStudio™ real-time PCR system (applied Biosystems) under the following cycling conditions: reverse transcription at 50˚C for 30 minutes, initial enzyme activation at 95˚C for 15 minutes, followed by 45 cycles of denaturation at 95˚C for 15 seconds and annealing/extension at 60˚C for 1 minute. Data acquisition and analysis were performed automatically using the fluorescence threshold defined by the instrument.

2.6. Statistical Analysis

The data were entered and analyzed using R software (version 4.3) and SPSS (version 26). Continuous quantitative variables were described using means, medians, and standard deviations, while qualitative variables were summarized as proportions and percentages. Comparisons between groups (rhinovirus positive vs. negative) were performed using Student's t-test or Mann-Whitney test, depending on the distribution of data for continuous variables, and chi-square or Fisher's exact test for categorical variables. The relationship between monthly rhinovirus circulation and climatic parameters (temperature, humidity, rainfall) was assessed using Pearson correlations for continuous quantitative variables, with a significance threshold set at $p < 0.05$. Seasonal trends were visualized using monthly graphs and time series to identify peak incidence periods and their coincidence with climatic variations. The results of the statistical tests are presented as correlation coefficients (r) accompanied by the corresponding p-values to indicate the strength and significance of the associations observed.

3. Results

Table 1 shows the patients' characteristics according to rhinovirus cases (2022-2023) in Côte d'Ivoire. A total of 4480 children hospitalized for acute respiratory infection were included. Among them, 182 (4.1%) tested positive for rhinovirus. The proportion of confirmed cases increased significantly between 2022 and 2023 (3.3% vs. 4.7%, $p < 0.021$), reflecting a notable temporal change in viral circulation. Rhinovirus-positive children were significantly younger than negative cases (median: 1 [0 - 2] months vs. 5 [1 - 32] months, $p < 0.001$), indicating increased vulnerability in infants, particularly during the first 12 months of life, when the majority of infections were concentrated (67.6% of positive cases). The distribution by gender showed no significant difference between the groups (3.7% in boys vs. 4.4% in girls; $p > 0.05$), suggesting similar exposure regardless of gender. In addition, no marked differences were observed in clinical status (ILI vs. SARI; $p = 0.313$), indicating that rhinovirus does not appear to be associated with a more

severe presentation. In terms of symptoms, cough was present in almost all infected children (98.4%), but its frequency was not significantly different from that observed in negative cases (p = 0.202). Conversely, fever was significantly more frequent in the rhinovirus-positive group (81.9% vs. 75.7%, p < 0.001), indicating an exacerbated inflammatory response. Certain digestive symptoms, particularly diarrhea, were less common in positive patients (p = 0.047), suggesting a primarily respiratory clinical involvement. Impaired consciousness, although rare, was significantly more frequently reported in the positive group (1.1% vs. 0.2%, p = 0.002), which warrants particular clinical attention. Overall, these results highlight that rhinovirus preferentially affects very young children and is associated with predominantly moderate clinical forms, dominated by fever and cough without significant progression to severe forms. However, the rare occurrence of neurological symptoms requires continued vigilance.

Table 1. Patient's characteristics according to rhinovirus cases (2022-2023).

Patients characteristics	Rhinovirus positive cases	Rhinovirus negative cases	p-value
	n (%)	n(%)	
	year		<0.021
2022 (n = 2061)	68 (3.3)	1993 (96.7)	
2023 (n = 2419)	114 (4.7)	2305 (595.3)	
Age (month) Median (IQR)	1821 (0 - 2)	42,985 (1 - 32)	<0.001
Age group			
0 - 12 months	123 (4.2)	2841 (95.0)	
13 - 24 months	33 (5.0)	633 (95.0)	
25 - 36 months	10 (2.4)	411 (97.6)	
≥37 months	16 (3.7)	413 (96.3)	0.202
	sex (n = 4480)		
Male (n = 1991)	73 (3.67)	1918 (96.33)	
Female (n = 2489)	109 (4.4)	2380 (95.6)	
Clinical status (n = 4480)			0.313
ILI (n = 2708)	103 (3.8)	2605 (96.2)	
SARI (n = 1772)			
	Clinical symptoms		
Fever	149 (81.9)	3357 (95.8)	<0.001
Cough	179 (98.4)	4262 (96.0)	0.202
Diarrhea	8 (4.4)	333 (7.8)	0.047
Vomiting	31 (17.0)	724 (16.8)	0.913
Consciousness impairment	2 (1.1)	9 (0.2)	0.002

The distribution of rhinovirus cases according to temperature (A), relative humidity (B), and rainfall (C) in Côte d'Ivoire (2022-2023) is shown in Figure 1.

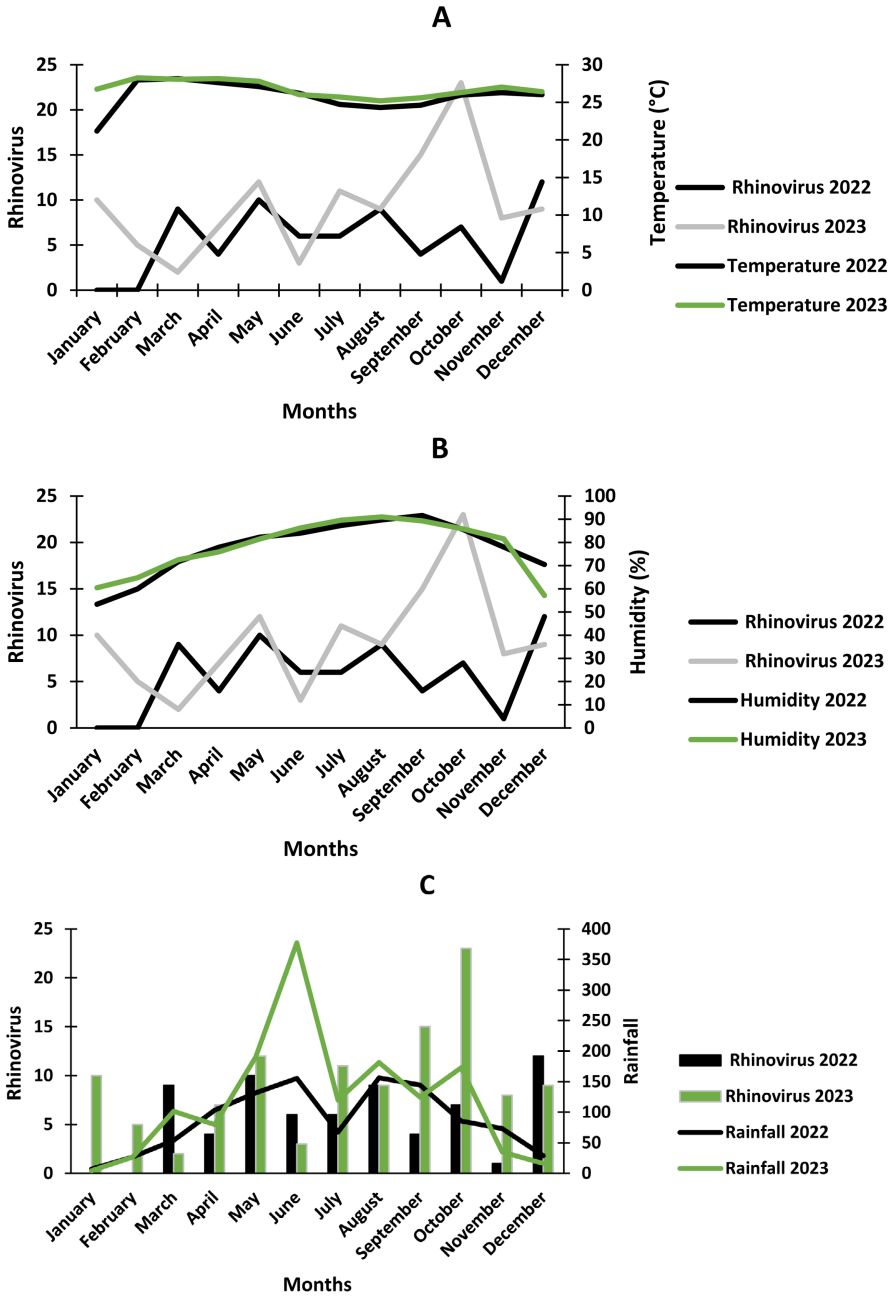

Figure 1. Distribution of rhinovirus cases according to Temperature (A), relative humidity (B) and rainfall (C) in Cote d'Ivoire (2022-2023).

Analysis of monthly rhinovirus circulation in 2022 and 2023 shows seasonal variation influenced by climatic parameters. Average monthly temperatures ranged from 21.2˚C to 28.2˚C in 2022 and from 25.2˚C to 28.3˚C in 2023, with a tendency for cases to increase during relatively cooler months and decrease during warmer periods. This inverse relationship is confirmed by a weak and non-significant cor-

relation in 2022 ($r = 0.24$; $p = 0.45$) and a moderately negative correlation in 2023 ($r = -0.39$; $p = 0.21$). Relative humidity, which was high overall during the period, peaked in October, coinciding with the peak in viral incidence. A moderate positive correlation, although not significant, was observed between humidity and the number of cases in 2022 ($r = 0.43$; $p = 0.16$) and in 2023 ($r = 0.32$; $p = 0.31$), suggesting a favorable effect of humidity on viral persistence. Finally, rainfall showed a significant positive association with rhinovirus circulation ($r = 0.58$; $p < 0.05$), with peaks in incidence coinciding with rainy seasons, while episodes of heavy rainfall and heat appear to limit transmission. These results indicate that climatic conditions characterized by moderate to high temperatures, high humidity, and regular rainfall favor rhinovirus circulation in Côte d'Ivoire.

4. Discussion

This study provides a detailed analysis of rhinovirus circulation among children under five years of age in Côte d'Ivoire over the period 2022-2023, revealing an overall prevalence of 4.1%, with a significant increase between the two years. These results confirm the importance of rhinoviruses as frequent agents of acute respiratory infections in children, consistent with observations reported in other tropical and temperate countries [2] [3]. The median age of infected children (1 month) highlights the increased vulnerability of infants, which is consistent with previous studies demonstrating that limited maternal immunity and early exposure increase the risk of infection [1] [5]. The monthly distribution of infections highlights seasonal variations influenced by climatic factors. Rhinovirus incidence tends to increase during months with relatively low temperatures and decrease during warmer periods, although the correlation between temperature and rhinovirus infection was not statistically significant ($r = 0.24$ in 2022; $r = -0.39$ in 2023). This result may be explained by the small range of temperature variations in the study region, limiting the potential effect of temperature on viral transmission. In contrast, rainfall showed a significant positive association with viral circulation ($r = 0.58$; $p < 0.05$), suggesting that the wet season favors virus spread. This phenomenon could result from increased ambient humidity and changes in human behavior: during rainy periods, individuals tend to spend more time in enclosed spaces—homes, classrooms, or community settings—which increases close contact and crowding, two conditions conducive to the transmission of respiratory viruses. Furthermore, high humidity may also influence transmission dynamics: studies indicate that in tropical or subtropical regions, elevated humidity promotes the deposition of respiratory droplets on surfaces and prolongs the survival of the viruses they contain, thereby increasing the risk of indirect transmission. These observations are consistent with data from [11] who report that rhinoviruses survive better and are transmitted more efficiently at moderate temperatures than at extreme temperatures. High relative humidity, peaking in October, coincides with peak viral circulation, and although the statistical correlations are weak and not significant, they suggest that humidity plays a favorable role in the persis-

tence of the virus in the environment, as reported by Shaman *et al.* (2011) and Lowen *et al.* (2014) in similar contexts [12]. Precipitation showed a significant positive correlation with viral circulation ($r = 0.58$; $p < 0.05$), suggesting that the rainy season is a factor favoring transmission. This phenomenon could be explained by increased ambient humidity combined with changes in human behavior. During periods of frequent rainfall, individuals tend to spend more time in enclosed spaces such as homes, classrooms, or community settings which increases close contact and crowding, both conditions conducive to the spread of respiratory viruses. Furthermore, high humidity may influence transmission dynamics: studies show that in tropical or subtropical regions, elevated humidity promotes the deposition of respiratory droplets on surfaces and prolongs the survival of the viruses they contain, thereby increasing the risk of indirect transmission through contact or fomites [13].

Clinically, the study confirms that the typical presentation of rhinovirus infections in young children remains moderate, dominated by cough and fever, with no significant differences between ILI and SARI. However, the slightly increased frequency of rare neurological symptoms in positive children, although marginal, requires monitoring. These data are consistent with the findings of Bénie *et al.* (2019) and Chartrand *et al.* (2010), indicating that rhinoviruses, although often benign, can occasionally cause severe complications, particularly in infants or children with comorbidities [14].

Recent studies have shown that rhinovirus can cause clinically severe infections in young children. Erkkola *et al.*, 2020 observed that human rhinovirus type C (HRV-C) was associated with severe wheezing episodes and febrile infections in children aged 3 to 23 months, indicating that this virus is not limited to mild infections. Complementarily, Asner *et al.*, 2014 reported in a retrospective study that HRV/enterovirus infections sometimes led to more severe outcomes than infections caused by other respiratory viruses such as RSV or influenza, with higher rates of hospitalization and complications. These findings highlight the clinical significance of rhinovirus in pediatric respiratory morbidity [15] [16].

Overall, this study demonstrates that rhinovirus infections in Côte d'Ivoire exhibit clear seasonality influenced by local climatic conditions, particularly rainfall and relative humidity, with a moderate impact from temperature variations. These results highlight the importance of integrating environmental factors into the planning of strategies for monitoring and preventing respiratory infections in young children in tropical countries.

5. Conclusion

This study highlights that rhinovirus is a major cause of respiratory infections in children under five years of age in Côte d'Ivoire, with a higher incidence among infants. Viral circulation exhibits seasonality closely linked to climatic conditions, particularly high humidity and heavy rainfall, while the influence of temperature remains moderate. Rhinovirus infections generally remain benign, although the

overall clinical picture is moderate, with rare but serious neurological symptoms that may occur and require special monitoring. These findings provide essential information for strengthening surveillance strategies and planning preventive interventions against viral respiratory infections in tropical countries.

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Conflicts of Interest

The authors have not declared any conflicts of interest.

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