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ORIGINAL

Clinical epidemiological behavior of pneumonia and re-emergence of pathogens in the post-pandemic era

Comportamiento clínico-epidemiológico de la neumonía y reemergencia de patógenos en la era postpandemia

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ABSTRACT

Introduction: pneumonia remains the leading cause of global morbidity and mortality in children. After the COVID-19 pandemic, the biosecurity measures applied reduced the transmissibility of the virus; however, after the relaxation of the restrictions, there is evidence of virus circulation with changes in seasonality. The objective of the study was to determine the clinical-epidemiological profile and etiological agents involved in pneumonia in children admitted to the Ambato General Hospital in the post-pandemic era.
Method: prospective, observational and analytical study that evaluated 100 children with a diagnosis of pneumonia, aged between 1 month and 10 years, in the period September 2023 to August 2024. Nasopharyngeal swab samples were processed in the microchip array system and clinical and paraclinical variables were analyzed.
Results: the most affected age group was 37 to 60 months; gestational age influenced clinical severity but not exclusive breastfeeding. The etiologic agents identified were respiratory syncytial virus RSV (31 %), rhinovirus/enterovirus (23 %), metapneumovirus (20 %), with september being the month of highest circulation; wet cough, rhinorrhea, respiratory distress and rales were the frequent clinical expression. CRP was not related to severity; hemogram showed an inverse relationship between leukocytes and lymphocytes. Interstitial and alveolar interstitial radiological pattern was the most frequent.
Conclusions: pneumonia continues to be a threat to children under 5 years of age. After the pandemic, the seasonality and behavior of viruses and bacteria changed, with outbreaks of pneumonia and unusual respiratory infections.

Keywords: Children; Pneumonia; Nasopharyngeal Swab; Virus.

RESUMEN

Introducción: la neumonía sigue siendo la principal causa de morbimortalidad global en niños. Tras la pandemia de COVID-19, las medidas de bioseguridad aplicadas disminuyeron la transmisibilidad del virus,

sin embargo, luego de la relajación de las restricciones, se evidencia circulación de virus con cambios en la estacionalidad. El objetivo del estudio fue determinar el perfil clínico-epidemiológico y agentes etiológicos implicados en la neumonía en niños ingresados en el Hospital General Ambato en la era postpandemia.
Método: estudio prospectivo, observacional y analítico que evaluó a 100 niños con diagnóstico de neumonía, con una edad entre 1 mes y 10 años, en el período septiembre 2023 a agosto 2024. Se procesaron muestras de hisopado nasofaríngeo en el sistema de microchips array y se analizaron variables clínicas y paraclínicas.
Resultados: el grupo de edad más afectado fue el de 37 a 60 meses, la edad gestacional influyó en la gravedad clínica mas no la lactancia materna exclusiva. Los agentes etiológicos identificados: *virus sincitial respiratorio* VSR (31 %), *rinovirus/enterovirus* (23 %), *metapneumovirus* (20 %), siendo el mes de septiembre el de mayor circulación; la tos húmeda, rinorrea, dificultad respiratoria y estertores fueron la expresión clínica frecuente. La PCR no se relacionó con la gravedad, el hemograma evidenció una relación inversa entre leucocitos y linfocitos. El patrón radiológico intersticial y alveolo intersticial fue el más frecuente.
Conclusión: la neumonía continúa siendo una amenaza para niños menores de 5 años, posterior a la pandemia se modificó la estacionalidad, el comportamiento de virus y bacterias, con brotes de neumonía e infecciones respiratorias inusitadas.

Palabras clave: Niños; Neumonía; Hisopado Nasofaríngeo; Virus.

INTRODUCTION

Severe pneumonia in the pediatric population is a significant cause of global morbidity and mortality, an inflammatory and infectious disease of the lung parenchyma, affecting the quality of life of the patient and family and constituting an economic burden for health systems in developing countries.

Every year, more than 725000 children under the age of five die from pneumonia, of which about 190000 are newborns; at least one child dies from pneumonia every 43 seconds, and virtually all of these deaths could be prevented.

Worldwide, 156 million cases of pneumonia have been reported each year, and between 7 and 13 % can become severe cases. In Ecuador in 2025, according to the National Directorate of Epidemiological Surveillance, 39922 cases of pneumonia were reported nationally up to week 13.[1,2]

In 2019, the COVID-19 pandemic began in China and spread worldwide, with a global epidemiological impact, modifying the epidemiology and etiology of pneumonia. Before the pandemic, streptococcus pneumonia, mycoplasma pneumonia, and respiratory syncytial virus (RSV) were the frequent agents in children under 5 years of age; during the pandemic, quarantine, biosecurity measures and distancing reduced the transmissibility of the virus, with a very low mortality rate in children of 0,08 %.[3,4]

It appears that children tend to be less susceptible to severe respiratory infections than adults, probably due to a strong immune response, healthier airways, less exposure to environmental pollutants and tobacco smoke, in addition to cross-reactivity between the immune response to vaccines in early childhood that generates immunological memory for non-specific immune protection, as well as immature angiotensin-converting enzyme receptor 2 (ACE2) function, which results in a lower inflammatory response to viral loads, plus adequate nutrition and low prevalence of chronic diseases. These could qualify as potential protective factors against COVID-19 in the pediatric population.[3,5]

However, after the relaxation of restrictions and the return to everyday life, a resurgence of more severe respiratory infections and the emergence of new virus strains was observed, probably due to the lack of exposure of the pediatric population to viruses and bacteria, which may have led to an 'immune debt,' characterized by a decrease in protective immunity, leading to unusual and severe infections such as the 2021 epidemic of respiratory syncytial virus (RSV), which occurred off-season in summer in New Zealand and Australia and exceeded five times the infections of previous years. In Europe, an atypical winter with a longer than usual duration, the typical annual spring epidemic of human metapneumovirus was observed in autumn-winter 2021-2022, causing severe respiratory infections.[6] Climate change has caused an average temperature increase of 1,2 degrees Celsius, and phenomena such as heat waves, floods, droughts, changes that affect the climate, viral biology, and human susceptibility, favoring the transmission of pathogens.[7,8]

This causes infections to appear out of season, altering the immunization schedule with delays in their application and even a lack of biologicals, which caused rebounds, such as the rotavirus epidemic in 2021. Epidemiological surveillance is necessary throughout the year to make quick and correct decisions in the face of this health problem.[9]

The diagnosis of community-acquired pneumonia (CAP) is based on clinical history and physical examination; the clinical expressions are cough, fever, signs of respiratory distress, thermal rise, and the presence of dry and moist rales on pulmonary auscultation.

Reactants such as C-reactive protein (CRP) and procalcitonin help us discriminate between viral and bacterial pneumonia; chest radiography is not routinely performed to diagnose pneumonia, while the use of lung ultrasound is a non-invasive test that can detect consolidation, pleural effusion, pneumothorax, and pulmonary edema.[10] Treatment is according to the clinical, paraclinical, and aetiological agents involved by age groups.[11,12]

The present study aims to demonstrate the clinical-epidemiological behaviour of post-pandemic pneumonia, providing a comprehensive understanding of the current situation and highlighting the importance of identifying the aetiological agents for proper pneumonia management and implementation of prevention strategies in this new era.

METHOD

This prospective, observational, analytical study evaluated 100 children with a clinical and radiological diagnosis of pneumonia admitted to the Paediatric Department of the Hospital General Ambato, aged between 1 month and 9 years 11 months, from September 2023 to August 2024. Patients with comorbidities were excluded: immunodeficiency, previous hospitalization for pneumonia in the last 8 weeks, chronic respiratory, neurological, and cardiac disease, congenital malformations, sickle cell anemia, gastro-oesophageal reflux, neoplasms, and tuberculosis.

Sampling

One hundred nasopharyngeal swab samples from selected patients were analyzed; the sample was placed in a tube with a transport medium and stored at 4 to 8 degrees Celsius. The samples were processed in the microchip array system, extracting and purifying all nucleic acids from the sample; in the first stage, a single large volume and massive nested multiplex PCR was performed, and in the second stage, single plex PCR, the products of the first stage were detected, generating a result.

The clinical and paraclinical data of the patients were obtained from the MIS AS400 system. Together with the respiratory panel results, they were compiled in a database to be analyzed in the statistical program SPSS, applying descriptive, inferential, and linear regression.

RESULTS

Of the total universe studied (100 patients), 36 % were male and 64 % female, with the most affected age group being 37 to 60 months.

Regarding risk factors, a chi-square test was performed to evaluate the relationship between gestational age and clinical severity, as measured by the Downes Score. The analysis yielded a p-value of 0,005, indicating that the severity of bronchoconstriction varies significantly depending on the gestational age of the patients. Breastfeeding was also studied, and an OR of 1,611 with a confidence interval (0,677 to 3,837) was obtained. This means that the difference is not statistically significant, i.e., exclusive breastfeeding does not influence the severity of pneumonia.

The most frequently observed clinical expression: wet cough 69 %, rhinorrhoea and fever 65 %, dry cough 33 %, odynophagia 11 %, diarrhea 14 % and chest pain 6 %; other symptoms also present were vomiting, stridor, and abdominal pain, it is essential to mention that recurrence of symptoms occurred in 15 %. Signs present in the children on admission: retractions 96 %, tachypnoea 87 %, respiratory distress 63 %, crepitant rales 81 %, signs of bronchospasm (rhonchi/wheezing) in 57 %, tachycardia 63 %, cervical lymphadenopathy 31 %. Qualification with the Downes score modified by Ferrez applied showed mild respiratory distress between 0 - 3 in 2 %, moderate (between 4 -7) in 98 %, and severe from 8 - 10 (0 %) (table 1).

Table 1. Most common clinical signs and symptoms

	Female	Male	Total
Retractions	63	33	96
Tachypnea	56	31	87
Crackles	51	30	81
Wet cough	43	26	69
Fever	40	25	65
Rhinorrhea	45	20	65
Respiratory distress	39	24	63

Tachycardia	41	22	63
Bronchial obstruction rhonchi/ wheezing	33	24	57
Dry cough	23	10	33
Cervical lymphadenopathy	20	11	31
Recurrence of symptoms	11	4	15
Diarrhea	6	8	14
Odynophagia	7	4	11
Chest pain	5	1	6
Stridor	3	2	5
Dysphonia	3	1	4
Asthenia	3	0	3
Abdominal pain	1	1	2
Vomiting	2	0	2
Aphonia	1	0	1
Headache	0	1	1
Cyanosis	0	1	1
Febrile convulsions	1	0	1
Dyspnea	0	1	1
Myalgia	1	0	1
Otalgia	0	1	1
Axillary lymphadenopathy	1	0	1

In relation to the etiological agents identified we found Respiratory syncytial virus in 31 patients (31 %), Rhinovirus/enterovirus 23 (23 %), Metapneumovirus 20 (20 %), Parainfluenza 3 in 9 %, Influenza A in 9 patients (9 %), Covid-19 4 (4 %), Influenza A-B 2 (2 %), Influenza B, Parainfluenza 1 and Adenovirus 1 % each (table 2).

Table 2. Aetiological agents identified

		Gender		
		Male	**Female**	**Total**
AGENTS 1	Respiratory Syncytial Virus	15	16	31
	Rinovirus/Enterovirus	7	16	23
	Metaneumovirus	7	13	20
	Parainfluenza 3	5	4	9
	Influenza A	0	9	9
	COVID 19	0	4	4
	Influenza A-B	1	1	2
	Influenza B	0	1	1
	Parainfluenza Virus 1	1	0	1

Figure 1 shows the relationship between the number of white blood cells and the percentage of lymphocytosis, differentiated by gender (female in pink and male in blue). In general, the higher the number of white blood cells, the lower the percentage of lymphocytosis tends to decrease in both genders. However, the trend and dispersion vary slightly between males and females. About CRP, figure 2 shows that the trends

of the lines do not follow a clear or consistent pattern across the different levels of severity. Likewise, there is considerable dispersion between the different aetiological agents and Downes score values, concluding that no significant relationship exists between elevated CRP values with clinical severity and aetiological agent.

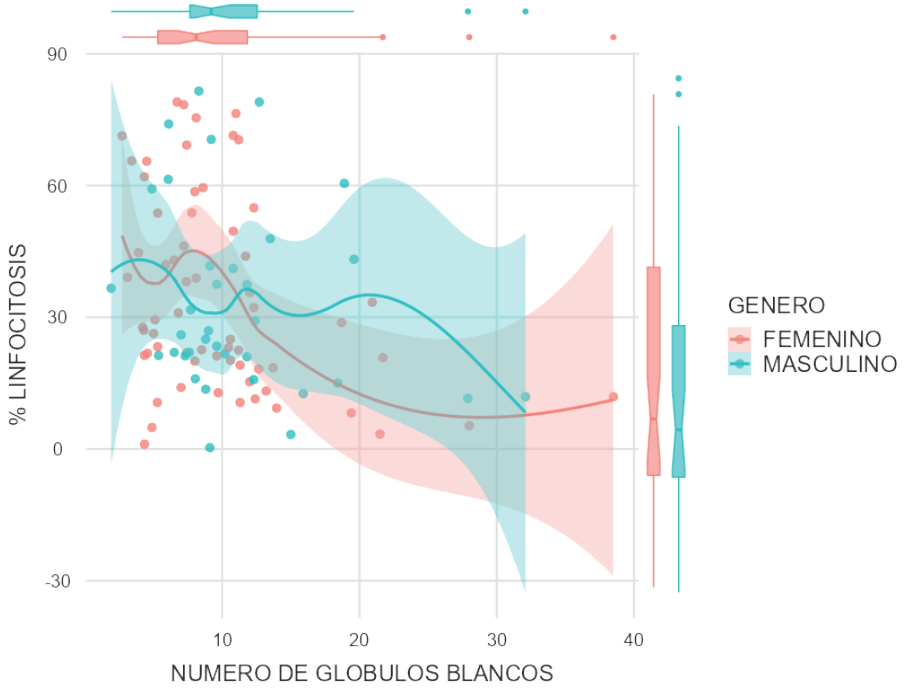

Figure 1. Leukocytosis VS Lymphocytosis

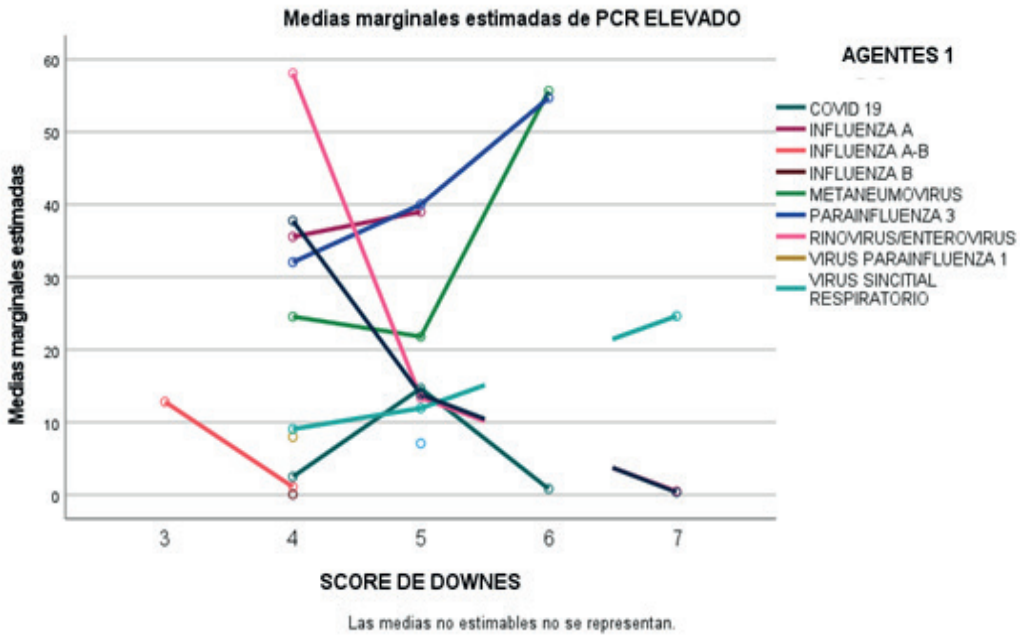

Figure 2. CRP VS Severity VS Aetiological agent

The most frequently observed radiological pattern was interstitial and alveolar interstitial, with 35 %, pulmonary hyperinflation, 40 %, condensation pattern, 18 %, and peribronchial enhancement, 15 %. The findings were bilateral and symmetrical in 92 %, unilateral in 5 %, and multifocal in 3 %.

One hundred patients were immunized, and 88 % were fully immunized according to the current immunization schedule; campaign vaccines covered only 37 % (SARS CoV 2) and 48 % for influenza. The average length of stay in the hospital was 6 days.

The highest number of patients admitted with pneumonia was in September, with 19 cases, followed by March 13, February 12, April 11, May 10, and June 8. Figure 3 shows that during February, March, April, and May, respiratory syncytial virus and metapneumovirus were the most frequently isolated agents, while in September, it was rhinovirus/enterovirus and parainfluenza 3. As for the correlation between the aetiological agent and the severity of pneumonia, as shown by the Downes score, it is observed that RSV and Rhinovirus/Enterovirus caused the most significant respiratory distress (figure 4).

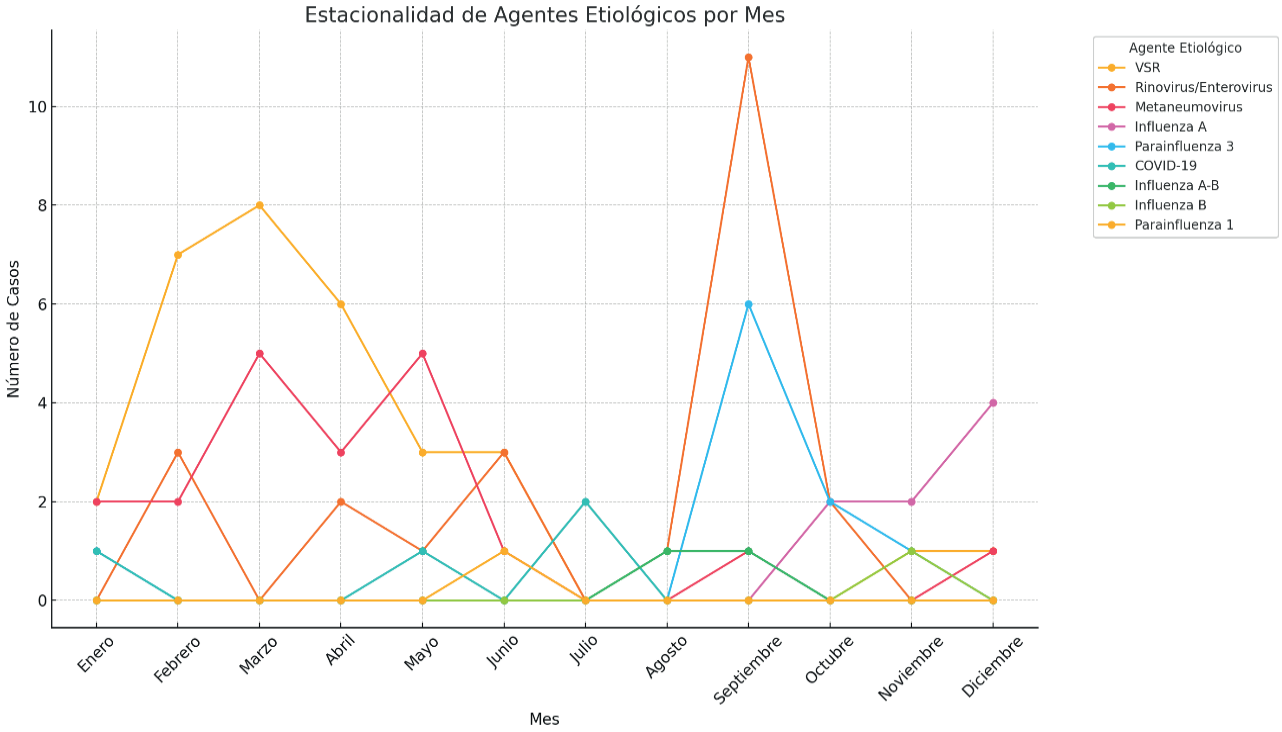

Figure 3. Seasonality of aetiological agent by month

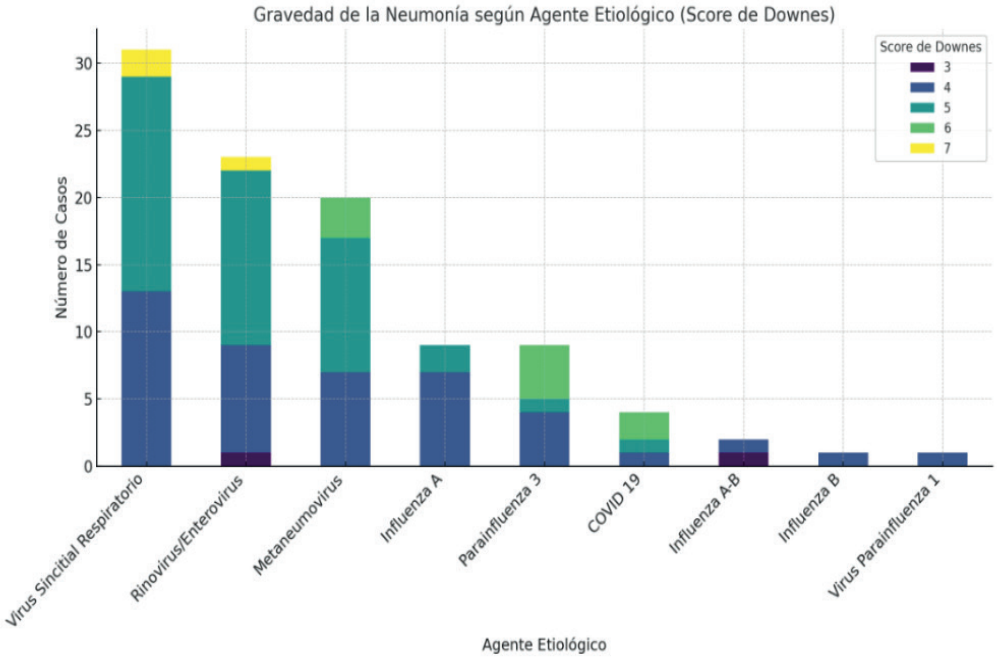

Figure 4. Downes Score VS Aetiological agent

DISCUSSION

The study included 100 patients with a diagnosis of pneumonia; the age group with the highest prevalence was

between 37 and 60 months, data that are consistent with several studies conducted in Ecuador, India, Nigeria, Pakistan, the Democratic Republic of Congo, Ethiopia, Korea, the United States, and Europe, countries with different levels of per capita income to ours, which reaffirms the higher prevalence of pneumonia worldwide in children under 5 years of age.[13,14,15,16] The most affected gender was female (64 %), a situation similar to the results obtained by Corvalán et al., but which disagrees with Sánchez et al., despite being a study carried out in our country. Overall, the male gender is the most affected, the possible cause being that females may have a higher resistance to infectious diseases due to their higher Th1 immune response and that prepubertal boys have shorter airways than girls of the same age, which could increase their susceptibility to lower respiratory tract infections.[14,17,18]

The majority of patients come from urban areas and, to a lesser extent, from rural parishes, data similar to those presented by Cáceres et al. These results are due to atmospheric pollution and the socialization of children in larger circles such as nurseries and schools, which predisposes them to infection by respiratory pathogens.[19]

Gestational age is a factor related to clinical severity, which ratifies Paredes et al., stating that prematurity is a vulnerability variable. Breastfeeding was also evaluated in patients without showing a relationship with the severity of pneumonia, in contrast to Qu et al., Fuentes et al., and Manzanares et al., who point to exclusive breastfeeding for more than 6 months as a protective factor against pneumonia.[20,21,22,24]

The frequent clinical expression is wet cough and rhinorrhoea, thermal rise, retractions, tachypnoea, respiratory distress, and dry and moist rales, similar to data published in the literature and in various studies such as Fuentes et al. and Alens et al.[22,23,24] To determine the severity of respiratory distress; the modified Wood-Downes scale was used, obtaining a score of moderate severity in 98 patients, similar to the results found by Delgado et al. where a moderate score was characteristic in hospitalized children with pneumonia.[25]

The increase of leukocytes in the haemogram was associated with a drop in lymphocytes. This situation can be explained by the fact that in a viral or bacterial infection, leukocytes increase, followed by a release of oxygen-free radicals that destroy the virus-cell wall, producing a high number of neutrophils; at the same time, the release of TCD8+ lymphocytes increases, but with a reduction of TCD4+ lymphocytes, resulting in suppression of cellular immunity and lymphopenia.[26]

C-reactive protein (CRP) was also evaluated, concluding in the present investigation that it is not related to clinical severity, in discordance with the results obtained by Barak et al., who observed an association between higher levels of CRP with an increase in days of hospital stay but the cases were of bacterial etiology; this acute phase reactant is related to bacterial infections in 45 %, with complications such as parapneumonic effusion or the need for admission to the pediatric intensive care unit.[27]

The aetiological agents isolated were viruses in the total sample: respiratory syncytial virus, followed by rhinovirus/enterovirus, metapneumovirus, parainfluenza 3, influenza A, COVID-19, influenza A-B, influenza B, parainfluenza 1, and adenovirus. These results are in line with studies conducted worldwide and dissimilar to those of a study conducted in Mexico, where the most prevalent agent was identified as the influenza A virus.[12,28,29]

The severity of pneumonia was related to RSV and Rhinovirus/Enterovirus infection. It has been shown that respiratory epithelial cells infected by these viruses induce the production of proinflammatory cytokines and chemokines: IL 1, 6, and 8 related to bronchoconstriction; thus IL-1 in airway smooth muscle enhances contractile responses to virulence factors; this initial response is amplified by migration of immune cells such as neutrophils, macrophages, dendritic cells, and NK cells, which cause leukocyte infiltration with release of elastase and myeloperoxidase leading to apoptosis of epithelial cells and release of detritus and mucus into the bronchial lumen, worsening bronchospasm and alteration of the ventilation/perfusion gradient.[30]

It is relevant to mention that during post-candidaemia, pathogen positivity rates and the proportion of severe cases increased, according to studies by Chen et al. and Lan et al.[31,32] In 2020, influenza B had a greater impact in Peru, Colombia, Argentina, and Brazil, where it was responsible for 1/3 of influenza hospitalizations in the first weeks of the year.[33] Regarding seasonality, in the present study, a higher frequency of admissions was observed during September and February to June, data that are related to research conducted in Colombia but which differ from studies conducted in Panama, where the highest peak was in July, a seasonality similar to research in Mexico where the highest frequency was observed in November to March.[34,35,36] According to the aetiological agent, Nuñez et al. describe the highest frequency of RSV in the months from June to October in Panama, in contrast to the present study, which shows that the months from January to May were those with the highest circulation of this virus.[35]

Sosa et al. describe interstitial as the most frequent radiological pattern, while Cemeli et al. and Coronado et al. indicate that the main finding was the alveolar pattern in a sample of children aged 1 to 14 years, similar to the radiological pattern found most frequently in the present study. Arnold et al. and Yun et al. describe in their results that the condensation pattern was predominant in children under 15. However, the most frequent etiology was bacterial.[29,37,38,39,40]

It is important to note that the present investigation showed that radiological patterns vary significantly

according to the infectious agent identified but not with clinical severity. The respiratory syncytial virus most frequently showed an interstitial pattern accompanied by peri-bronchial reinforcement in 25 %, rhinovirus showed a mixed alveolar-interstitial pattern with pulmonary hyperinflation in 68 % of cases, and metapneumovirus showed mostly an alveolar-interstitial pattern accompanied by a peribronchial enhancement in 20 %. These data resemble those Stefanidis K et al. described, where the peribronchial pattern was present in all these viruses.[41]

According to Von Mollendorf et al., viral and bacterial pathogens remain a significant cause of pneumonia in children, which reinforces the recommendation to keep immunizations up to date, particularly pneumococcal conjugate vaccine (PCV) and Haemophilus influenzae type b vaccine (Hib). Viral pneumonia has gained relevance recently, with respiratory syncytial virus being the primary agent involved, which has led to the development of vaccines against this pathogen.[42] The influenza virus implicated in 12 % of cases coincides with the absence of specific immunization; it is imperative to achieve immunization rates against influenza in the population under 5 years of age, following WHO recommendations, to reduce the morbidity and mortality associated with this disease and its impact on the community.[10] The impact of the relationship between the pandemic and vaccine-preventable diseases (VPEs) and vaccine coverage in Latin America is indisputable. It has led to outbreaks in different regions of the Americas.[42]

The average length of hospital stay was 6 days, in contrast to that reported by Delgado et al. with a mean length of stay of 7,28 days, which may be biased as all their patients had a diagnosis of respiratory syncytial virus pneumonia but is in agreement with Zhang et al., who report a mean length of hospital stay of 7,1 days and a similar aetiological profile in their study. On the other hand, Calzada et al. describe an average length of stay of 5 to 8 days in children with pneumonia, which would encompass all the aforementioned studies. Cashman et al. showed that health education provided to mothers had a positive influence, significantly reducing the length of stay in hospitals.[18,25]

CONCLUSIONS

Pneumonia remains a persistent threat and leading cause of childhood morbidity and mortality in Latin America, especially in children under five years of age. In the post-pandemic context, we have observed a significant change in epidemiological patterns, with RSV, rhinovirus, and metapneumovirus being the leading causes of viral pneumonia; contributing factors are high transmissibility through direct and indirect contact, alterations in herd immunity, and the reconfiguration of respiratory pathogen circulation, seasonality, and climatic conditions.

This study provides critical epidemiological data and contributes to the 'One Health' strategy that integrates environmental and social factors, allowing a preventive approach against epidemic pneumonia in the post-COVID-19 era in the Latin American pediatric population. Accurate identification of causative agents (viral, bacterial, or co-infections) is essential to optimizing clinical management, guiding therapeutic decision-making, and adjusting vaccination strategies in regional settings with a high burden of respiratory disease and limited resources. In the presence of seasonal viral pneumonia, the responsible use of antibiotics is encouraged.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

STATEMENT OF THE INSTITUTIONAL ETHICS COMMITTEE

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Technical University of Ambato (protocol code COD. 154-CEISH-UTA-2023, approved on 30 June 2023).

INFORMED CONSENT STATEMENT

Informed consent was obtained from all legal representatives of study participants.

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