INTRODUCTION
In November 2019, an outbreak of pneumonia of unknown etiology began in Wuhan, China, which was then identified as a new coronavirus, known as SARS-CoV-2. (1,2) The first cases of the disease in the pediatric population appeared at the beginning of the pandemic. (3)

Most cases of this infection in the pediatric population are asymptomatic or present with mild symptoms. (3–5) However, the presence of previous comorbidities is a risk factor for the development of severe disease. (6) Studies show that half of the COVID-19 patients admitted to intensive care units (ICU) and nearly 80% of those hospitalized had at least one comorbidity prior to admission. (4,6) Moreover, approximately 46% of pediatric patients with COVID-19 require hospitalization, and around 10% require intensive care; the mortality rate is 5.7%. (3,4,7,8)

COVID-19 has been shown to cause many aftereffects, including impairment of respiratory and muscle functions, reduced functionality, and difficulty performing daily tasks. (9,10) These changes can manifest in children as loss of motor milestones and delay in motor development. (10–12) Among the several professionals who work in the treatment of COVID-19, physical therapists are involved in the treatment, prevention, and rehabilitation of the functional changes caused by the disease. Thus, the assessment of the functional status of patients with COVID-19 at the time of hospital admission could contribute to the screening of more critically ill patients and assist in physical therapy during hospitalization.

Few studies analyze the functional profile of hospitalized children with COVID-19. The pediatric population usually shows mild symptoms of the disease, but children with previous comorbidities are more likely to develop severe cases of COVID-19, thus requiring hospitalization. Therefore, the functional profile of these children must be assessed to prepare the healthcare system for their admission, as well as intensify preventive practices and plan better physiotherapeutic strategies for adequate treatment.

Thus, the aim of the present study was to verify the prevalence of altered functioning in pediatric patients diagnosed with COVID-19 admitted to the pediatric inpatient unit of the Hospital de Clínicas de Porto Alegre (HCPA).

METHODS
A prospective cohort study was conducted in children diagnosed with COVID-19 admitted to the HCPA from 1/6

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ABSTRACT
Objective: The present study aimed to assess the functional status of children diagnosed with COVID-19 at the time of hospitalization and the associations with clinical features.

Methods: This prospective cohort study was carried out with children diagnosed with COVID-19 admitted to a tertiary hospital. The patients’ functioning was assessed using the pediatric Functional Status Scale (FSS).

Results: A total of 62 children with a median age of 3 years old were included in the study, and 70% had some comorbidity prior to the diagnosis of COVID-19. The median length of stay was nine days, during which period five patients died. The FSS assessment of the sample showed that approximately 55% had some functional alteration. The group of patients with the highest FSS scores presented a lengthier hospital stay (p = 0.016), required more oxygen therapy (p < 0.001), mechanical ventilation (p = 0.001), and intensive care unit admissions (p = 0.019), and had more cardiac (p = 0.007), neurological (p = 0.003), and respiratory (p = 0.013) comorbidities. In the multivariate analysis, there was an association between the dependent variable length of stay and the total FSS score (β = 0.349, p = 0.004) and the presence of comorbidities (β = 0.357, p = 0.004).

Conclusions: We observed that more than half of the children hospitalized due to COVID-19 had some level of functional change. Greater alterations in functional status were associated with the presence of previous comorbidities, a greater need for ventilatory support, and longer hospital stays.

Keywords: COVID-19, coronavirus, pediatrics, physical functional performance, functional status.
March 2020 to June 2021. This study was approved by the Research Ethics Committee of the HCPA, under Protocol No. 48189021400005327, according to Resolution 466/2012 of the HCPA National Health Council.

The collection of clinical and sociodemographic data was performed with the aid of electronic medical records, and the analyzed variables were: date of hospital admission, ethnicity/skin color, sex, age, weight, presence of comorbidities (cardiac, respiratory, neurological, metabolic, and/or oncological), laboratory tests (C-reactive protein, d-dimers, and lymphocyte, leukocyte, and platelet counts), the need for ventilatory support (oxygen therapy, non-invasive, high-flow nasal cannula (HFNC), mechanical ventilation (NIV), and invasive mechanical ventilation (MV)), functional status assessed using the Functional Status Scale (FSS), the severity of involvement by COVID-19 (Ordinal Scale for Clinical Improvement), length of stay, and death. The latter was defined as a patient who died for any given reason.

Pediatric patients of either sex, aged less than 18 years old, with a positive result in the reverse transcriptase polymerase chain reaction (RT-PCR) test for SARS-CoV-2, who were hospitalized at the HCPA were included in the study. Those who refused to participate and cases of reinfection were excluded.

According to the institutional protocol for the management of patients with COVID-19, individuals with moderate to severe symptoms were hospitalized, as well as patients with previous comorbidities due to exacerbation of the underlying disease. Oxygen therapy was indicated for patients with peripheral oxygen saturation (SpO₂) < 93%, increased respiratory rate (RR) according to age, and/or signs of respiratory effort. In cases of SpO₂ > 93% with supplemental oxygen therapy > 5 L/min without signs of multiple organ failure, the use of an HFNC was indicated. NIV was indicated for cases of hypoxemic respiratory failure without a satisfactory response to oxygen therapy alone and/or HFNC. Patients with hemodynamic instability requiring vasoactive drugs, respiratory failure regardless of the support provided in the ward, a need for invasive MV, and other organic dysfunctions were transferred to the ICU. The criteria for the use of invasive MV were: severe acute respiratory syndrome, SpO₂ < 93% using HFNC or NIV, PaO₂/FIO₂ ratio < 200, and evident signs of respiratory distress. The criteria for hospital discharge were considered as the improvement of SpO₂ and RR to baseline levels or acceptable limits, with the stability of the patient’s condition, for at least 12 hours (ideally 24 hours).

The functionality of the patients was evaluated using the pediatric FSS, which was translated and validated for the Brazilian pediatric population. This scale assesses the following domains: mental status, sensory functioning, communication, motor functioning, feeding, and respiratory status. Each domain receives a final score ranging from 1 to 5, where 1 is considered "normal" and 5, "very severe dysfunction." The total scores ranged from 6 to 30, in which the results could be categorized as adequate functionality (6–7 points), mild dysfunction (8–9 points), moderate dysfunction (10–15 points), severe dysfunction (16–21 points), and very severe dysfunction (22–30 points). These data were collected from the physical therapy evaluations recorded in the electronic medical records of the study patients at the time of hospitalization. The evaluation of functional status is part of the standard assessment of the hospital's physical therapy service and is always performed within the first 24 hours of hospitalization. Prior to the beginning of the study, all the physical therapists involved underwent specific training.

The severity of COVID-19 was classified using the World Health Organization (WHO)'s Ordinal Scale for Clinical Improvement. This scale has domains ranging from 0 to 8 points, in which the results can be categorized as not infected (0 points), outpatient follow-up (1–2 points), hospitalization with mild disease (3–4 points), hospitalization with severe disease (5–7 points), and death (8 points).

Functional status was also evaluated using the Lansky scale, intended for individuals under 16 years of age, in which the patient's performance and well-being are assessed, including their ability to perform daily activities and functional capacity. The score on an ordinal scale ranges from 10 to 100, where 10 represents a child who does not get out of bed, and 100, a child who is fully active.

The sample size was calculated using the online version of the PSS Health tool. The mean FSS score was estimated with a 2.5-point absolute margin of error and a 95% confidence level. Based on an expected FSS standard deviation (SD) of 8.9 points (estimated from the interquartile range), the sample size was defined as 52 subjects. Considering 15% of losses, a total of 62 individuals were recruited.

All variables were expressed as number of cases (proportion), median, and interquartile range (IQR) (25 percentile and 75 percentile). The Shapiro-Wilk test was used to assess the normality of continuous variables. The individuals were classified into two groups for analysis: FSS score ≤ 9 points and FSS score ≥ 10 points. Non-parametric comparisons between groups were conducted using the Mann-Whitney U test. Spearman's correlation analysis (non-parametric data) was used for correlations between the global FSS score and other clinical variables. Univariate and multivariate linear regression were performed, considering the logarithm of length of stay as the dependent variable since it had asymmetric distribution. All data were stored in a Microsoft Office Excel 2019 spreadsheet and analyzed using the Statistical Package for the Social Sciences (SPSS), version 18.0, adopting a 5% statistical significance level (p < 0.05).

RESULTS
A total of 62 unvaccinated children diagnosed with COVID-19 were included in the study, 39 (62.9%) of...
whom were male and with a median age of 3 years old (0.4–10). Approximately 70% (n = 43) of the patients already had some comorbidity prior to the diagnosis of COVID-19. Around 8% were diagnosed with COVID-19 at the time of admission due to the underlying pathology and were asymptomatic. The median length of stay of patients was nine days (5–23); 26 patients required ventilatory support during hospitalization (41.9%), and five died (8.1%). The sample characterization data are shown in Table 1.

Table 2 shows the comparison between the groups of patients with FSS ≤ 9 points (preserved functionality or mild dysfunction) and FSS ≥ 10 points (moderate, severe, or very severe dysfunction). The group of patients with FSS ≥ 10 points had a longer hospital stay (p = 0.016), required more oxygen therapy (p < 0.001) and mechanical ventilation (p = 0.001), more admissions to the ICU (p = 0.019), and presented more cardiac (p = 0.007), neurological (p = 0.003), and respiratory (p = 0.013) comorbidities than children with FSS ≤ 9 points.

We found a moderately significant and positive correlation between the total FSS score and the length of hospital stay (r = 0.607, p < 0.001) and the severity of COVID-19 (r = 0.575, p < 0.001). The FSS score was also inversely correlated with the Lansky scale score (r = -0.664, p < 0.001).

Only 11 children in this sample required invasive mechanical ventilation and, consequently, used sedative analgesics and/or neuromuscular blockers. However, the functionality scale was evaluated in the first 24 hours of hospitalization, when the patients had not yet received invasive mechanical ventilation, showing no interference in the initial functionality assessment.

The univariate and multivariate linear regression data considering the dependent variable logarithm of length of stay are shown in Table 3.

**DISCUSSION**

In this study, we report the prevalence of functional changes in pediatric patients hospitalized with COVID-19 in a hospital in southern Brazil. In our sample, 69.4% of the patients had some comorbidity prior to COVID-19 diagnosis. The assessment via pediatric FSS showed that 53.2% of the individuals had some change in functioning, with 27.4% presenting moderate to very severe alterations. In the stratification of our data, patients with FSS ≥ 10 points had a higher prevalence of previous comorbidities (respiratory, neurological, cardiac, and metabolic), longer hospital stays, and required more ventilatory support and ICU admissions than those with FSS ≤ 9 points. In the correlation analysis, we observed a moderately significant and positive correlation of the total FSS score, the length of hospital stay, and the severity of COVID-19, and an inverse correlation with the Lansky scale score. The univariate analysis showed a significant association of length of stay, the FSS score, the presence of comorbidities, the Lansky scale score, and the severity of COVID-19. The multivariate analysis showed a significant association of length of stay, the FSS score, and the presence of comorbidities.

According to our data, the patients with greater functional changes (FSS ≥ 10 points) were the ones with the most comorbidities (83.3%). The presence of comorbidities is a risk factor for the development of more severe forms of the disease. The study by Woodruff et al. (2022) corroborates our findings by demonstrating that more than 50% of pediatric patients hospitalized with COVID-19 had at least one comorbidity prior to hospital admission. As observed herein, cardiac, respiratory, oncological, and neurological comorbidities are the most prevalent in the literature.

Most of the evaluated sample had at least one comorbidity before the diagnosis and hospitalization for COVID-19. Despite no prior assessment, the changes in functionality found at hospital admission may relate to the presence of previous comorbidities. Other studies suggest that patients with chronic diseases have impaired functioning, motor performance, and independence. Kolman et al. (2018) demonstrated that functional status and mobility are predictors of health and quality of life in neurological patients.

Our study showed that the group of patients with FSS ≥ 10 points had a longer duration of hospital stay. The length of stay at the hospital relates to the presence of previous chronic pathologies, as patients with comorbidities require more healthcare assistance. According to the literature, the length of hospital stay in pediatric patients with COVID-19

**Table 1. Characterization of the individuals hospitalized with COVID-19.**

| Characteristics | n = 62 |
|-----------------|-------|
| Male            | 39 (62.9%) |
| White           | 51 (82.3%) |
| Age (years)     | 3.0 (0.4–10) |
| SpO2 admission  | 98.5 (96–100) |
| FiO2 admission  | 21 (21–21) |
| Length of Stay (days) | 9 (5–23) |
| Comorbidities   | 43 (69.4%) |
| Asymptomatic    | 5 (8.1%) |
| Ventilatory Support | 26 (41.9%) |

**Functional Status Scale**

| Adequate Functionality | 28 (45.2%) |
| Mild Dysfunction       | 16 (25.8%) |
| Moderate Dysfunction   | 14 (22.6%) |
| Severe Dysfunction     | 1 (1.6%) |
| Very Severe Dysfunction| 2 (3.2%) |

**Ordinal Scale for Clinical Improvement (points)**

| Lansky Scale (points) | 70 (40–85) |
| Deaths               | 5 (8.1%) |

Data were expressed as n (%) or median (25 percentile –75 percentile). n = number of cases; SpO2 = oxygen saturation; FiO2 = fraction of inspired oxygen.
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 ranges from 1 to 20 days and shows less than 35% presence of comorbidities.\textsuperscript{(27–29)} The longer length of stay in our study may be due to the higher prevalence of comorbidities and the complexity of our sample. The study by Pollack et al., in 2009,\textsuperscript{(16)} evidenced that higher FSS scores at the time of hospital admission correlate with longer hospital stays and increased use of mechanical ventilation. In addition, patients with higher scores at discharge tend to have worse clinical outcomes in the subsequent three years.\textsuperscript{(30)} Thus, the assessment of the functional status of pediatric patients with COVID-19 during hospitalization can be considered a useful instrument that can assist in the physical therapy of groups at higher risk.

### Table 2. Comparison of the sample of pediatric individuals hospitalized with COVID-19 according to the presence of changes in functionality by the FSS.

| Characteristics         | FSS ≤ 9 points | FSS ≥ 10 points | p     |
|-------------------------|----------------|----------------|-------|
|                         | n = 44         | n = 17         |       |
| Male                    | 26 (59.1%)     | 13 (76.5%)     | 0.562 |
| Weight (kg)             | 12.1 (6.4–36)  | 11.8 (6.9–21.9) | 0.794 |
| Age (years)             | 2 (0.4–10)     | 2.5 (0.4–9)    | 0.924 |
| SpO\textsubscript{2} admission, % | 99 (97–100) | 98 (94–100)    | 0.487 |
| FiO\textsubscript{2} admission, % | 21 (21–21)     | 21 (21–28)     | 0.122 |
| PaO\textsubscript{2}/FiO\textsubscript{2} admission | 161.5 (94.5–288.1) | 109.9 (72.8–173.2) | 0.346 |
| Length of Stay (days)   | 7.5 (5–14)     | 21.5 (7–40)    | 0.016 |
| Comorbidities           | 28 (63.6%)     | 15 (88.2%)     | 0.265 |
| Cardiac Comorbidity     | 1 (2.3%)       | 5 (29.4%)      | 0.007 |
| Respiratory Comorbidity | 5 (11.4%)      | 8 (47.1%)      | 0.013 |
| Neurological Comorbidity| 4 (9.1%)       | 8 (47.1%)      | 0.003 |
| Metabolic Comorbidity   | 6 (13.6%)      | 5 (29.4%)      | 0.275 |
| Oncological Comorbidity | 11 (25%)       | 1 (5.9%)       | 0.089 |
| Immunosuppression       | 7 (15.9%)      | 1 (5.9%)       | 0.417 |
| Tracheostomy            | 0 (0%)         | 4 (23.5%)      | 0.006 |

### Ventilatory Support

| Oxygen Therapy          | 17 (38.6%)     | 17 (100%)      | <0.001 |
| HFNC                    | 7 (15.9%)      | 6 (35.3%)      | 0.176  |
| NIV                     | 3 (6.8%)       | 4 (23.5%)      | 0.180  |
| MV                      | 3 (6.8%)       | 8 (47.1%)      | 0.001  |
| ICU admission           | 11 (25%)       | 11 (64.7%)     | 0.019  |

### Clinical laboratory tests

| CRP                     | 13.8 (1.8–54.9) | 41.1 (7.3–112.9) | 0.328  |
| D-dimers                | 1.4 (0.6–2.2)   | 1.1 (0.6–3.6)   | 0.957  |
| Lymphocytes             | 3.4 (1.9–6.4)   | 2.1 (0.8–3.1)   | 0.144  |
| Leukocytes              | 9 (5.5–11.7)    | 7.8 (5.6–11.7)  | 0.816  |
| Platelets               | 289 (192-418)   | 229 (143-326)   | 0.337  |
| Deaths                  | 3 (6.8%)        | 2 (11.8%)       | 0.616  |

Data were expressed as n (%) or median (25 percentile - 75 percentile). FSS = Functional Status Scale; n = number of cases; kg = kilograms; SpO\textsubscript{2} = oxygen saturation; FiO\textsubscript{2} = fraction of inspired oxygen; PaO\textsubscript{2} = oxygen blood pressure; HFNC = high-flow nasal cannula; NIV = non-invasive ventilation; MV = mechanical ventilation; ICU = intensive care unit; CRP = C-reactive protein.

### Table 3. Univariate and multivariate linear regression analyses considering the dependent variable length of stay (logarithm).

| Characteristics         | Univariate | Multivariate |
|-------------------------|------------|--------------|
|                         | β  | CI         | p    | β  | CI         | p    |
| FSS, points             | 0.397 | 0.036–0.159 | 0.002 | 0.349 | 0.028–0.143 | 0.004 |
| Comorbidities           | 0.404 | 0.313–1.323 | 0.002 | 0.357 | 0.246–1.200 | 0.004 |
| Lansky scale, points    | -0.406 | -0.024–0.006 | 0.002 | - | - | - |
| Ordinal Scale for Clinical Improvement, points | 0.327 | 0.055–0.460 | 0.014 | - | - | - |

β = linear regression coefficient; CI = confidence interval.

ranges from 1 to 20 days and shows less than 35% presence of comorbidities.\textsuperscript{(27–29)} The longer length of stay in our study may be due to the higher prevalence of comorbidities and the complexity of our sample.

The study by Pollack et al., in 2009,\textsuperscript{(16)} evidenced that higher FSS scores at the time of hospital admission correlate with longer hospital stays and increased use of mechanical ventilation. In addition, patients with higher scores at discharge tend to have worse clinical outcomes in the subsequent three years.\textsuperscript{(30)} Thus, The group of children with FSS ≥ 10 points required more oxygen therapy, high-flow nasal cannula support, non-invasive mechanical ventilation, and invasive mechanical ventilation. Similar to other studies, few cases of children have progressed to the severe form of COVID-19. However, the presence of comorbidities

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is an incisive factor and is present in most patients who require ventilatory support and ICU hospitalization.\textsuperscript{3,11–33}

The role of COVID-19 in the functional changes of children remains unclear, as many children had previous comorbidities that contributed to such alterations.\textsuperscript{34} The need for ICU admission can also be associated with comorbidities and complex medical histories.\textsuperscript{34} COVID-19 can exacerbate a coexisting chronic disease or be an additional factor in a patient’s severe clinical course, as well as alter their functionality. Therefore, the influence of comorbidities and SARS-CoV-2 infection on the clinical outcome may be combined.\textsuperscript{28}

This study prospectively evaluated hospitalized children diagnosed with COVID-19 for one year and four months. It was conducted at a single center, which may limit the generalization of its findings to different populations. Additional studies are necessary to identify long-term outcomes, as are multicenter studies involving larger sample sizes. We did not assess the use of medications due to the heterogeneity of the analyzed sample. This can be considered a limitation of the study, as some drugs can influence some domains of the functional status scale. Despite these limitations, our study is one of the pioneers in the evaluation of the functioning of pediatric patients diagnosed and hospitalized with COVID-19 in Brazil.

In conclusion, functional changes were found in approximately 53% of the pediatric patients hospitalized with COVID-19 in a hospital in southern Brazil. Greater alterations in functional status were associated with the presence of previous comorbidities, greater need for ventilatory support, and longer hospital stays. The FSS is essential to assess the functional status of pediatric patients hospitalized with COVID-19 since it is validated for the Brazilian population, simple to apply, and crucial to assist in physical therapy management.

**AUTHOR CONTRIBUTIONS**

Literature search: GMC, CJS, GHA, DSM, LKBA, CM, and BZ; data collection: GMC, CJS, GHA, and BZ; study design: GMC, CJS, DSM, LKBA, CM, and BZ; data analysis: GMC, CJS, and BZ; manuscript preparation: GMC, CJS, GHA, DSM, LKBA, CM, and BZ; manuscript review: DSM, LKBA, CM, and BZ.

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