Rev Rene. 2024;25:e93486.
DOI: 10.15253/2175-6783.20242593486
www.periodicos.ufc.br/rene

Original Article

Influence of socioeconomic indicators on the COVID-19 pandemic in the child and youth population

Influência dos indicadores socioeconômicos na pandemia de COVID-19 na população infantojuvenil

How to cite this article:
Ribeiro AC, Falciroli IMV, Cano RN, Uehara SCSA. Influence of socioeconomic indicators on the COVID-19 pandemic in the child and youth population. Rev Rene. 2024;25:e93486. DOI: https://doi.org/10.15253/2175-6783.20242593486

Ana Cristina Ribeiro[1]
Isa Milene Vansan Falciroli[2]
Rodrigo das Neves Cano[3]
Silvia Carla da Silva André Uehara[4]

[1]Universidade Federal de São Carlos.
São Carlos, SP, Brazil.

Corresponding author:
Ana Cristina Ribeiro
Rodovia Washington Luis s/n, km 235
Caixa Postal 676. CEP: 13565-905
São Carlos, SP, Brazil.
E-mail: a.crisrib@gmail.com

Conflict of interest: the authors have declared that there is no conflict of interest.

EDITOR IN CHIEF: Ana Fatima Carvalho Fernandes
ASSOCIATE EDITOR: Jéssica de Castro Santos

ABSTRACT

Objective: to analyze the influence of socioeconomic indicators on the COVID-19 pandemic in the child and youth population. **Methods:** this is an ecological study, considering all reported cases of COVID-19 infection and deaths in children and adolescents. Secondary data was collected and analyzed using the Global Moran's Index, both univariate and bivariate. **Results:** the highest incidence rate of COVID-19 in the child and youth population was recorded in the Midwest; the highest mortality rate was found in the North; and the highest lethality rate was reported in the Northeast. There was also a negative correlation between COVID-19 mortality in the child and youth population and the Human Development Index, per capita income, and education level of the head of the household. **Conclusion:** Socioeconomic indicators related to the Human Development Index (HDI), nominal per capita income, and education level of the head of the family may have influenced the increase in incidence and mortality from COVID-19 in the child and youth population in Brazil. **Contributions to practice:** knowledge of regional socioeconomic inequalities helps to plan and implement public policies aimed at minimizing Brazil's regional inequalities in the face of health crises such as those experienced during the COVID-19 pandemic.

Descriptors: COVID-19; Socioeconomic Factors; Child; Adolescent.

RESUMO

Objetivo: analisar a influência dos indicadores socioeconômicos na pandemia de COVID-19 na população infantojuvenil. **Métodos**: trata-se de um estudo ecológico, considerando todos os casos de infecção e óbitos notificados de COVID-19 em crianças e adolescentes. Os dados secundários foram coletados e analisados por meio dos Índices de Moran Global, de forma uni e bivariada. **Resultados**: na região Centro-Oeste, foi registrado o maior coeficiente de incidência por COVID-19 na população infantojuvenil; na região Norte, foi verificado o maior índice de mortalidade e a maior letalidade foi notificada na região Nordeste. Ainda, foi observada uma correlação negativa entre a mortalidade por COVID-19 na população infantojuvenil e índice de desenvolvimento humano, rendimento per capita e escolaridade do chefe da família. **Conclusão**: os indicadores socioeconômicos relacionados ao Índice de Desenvolvimento Humano (IDH), rendimento nominal per capita e escolaridade do chefe da família podem ter influenciado no aumento da incidência e mortalidade pelo COVID-19 na população infantojuvenil no Brasil. **Contribuições para a prática:** o conhecimento das desigualdades socioeconômicas regionais auxilia para o planejamento e implementação de políticas públicas que tenham por finalidade minimizar as desigualdades regionais brasileiras diante as crises sanitárias como vivenciadas durante a pandemia de COVID-19.

Descritores: COVID-19; Fatores Socioeconômicos; Criança; Adolescente.

Received: May 29th 2024; Accepted: July 11st 2024.

Introduction

COVID-19, caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), is a disease that affects people of any age; however, during the critical phase of the pandemic, it had a lower incidence among the child and youth population. The fact that the immune system of this population group differs from that of adults and the aged could be considered the main reason why this age group was not so affected by the disease. However, when analyzing the mortality coefficient among children, an increase in these figures was observed, especially after the emergence of the delta and Omicron variants, although lethality was still lower when compared to adults and aged people[1].

Although the risk factors for COVID-19 complications in children and adolescents remain unclear, it is suggested that there are more vulnerable groups. In Brazil, a study analyzed more than 10,000 children and adolescents hospitalized for the disease and showed that those aged up to two years and 12 years or older were at twice the risk of infection compared to children aged 2 to 11 years. It also confirmed that pre-existing medical conditions, geopolitical region, and socioeconomic factors are factors associated with a higher risk of death from the SARS-CoV-2 infection[2].

Despite the lower incidence of COVID-19 cases and mortality in children and adolescents, the disease was the leading cause of death among infectious or respiratory diseases in people aged 0–19 years in the United States from 2019 to 2022[3]. In addition to the United States, the United Kingdom, Italy, Germany, Spain, France, and South Korea showed a higher mortality rate among children in the younger age groups, especially up to four years old; however, the differences between countries require careful interpretation, as they may be related to the organization of health systems and economic and social factors[4].

In Brazil, COVID-19 was the leading cause of death from vaccine-preventable diseases in children under 19 between August 2021 and July 2022, with the North and Northeast regions recording the highest lethality coefficients. Thus, the incidence and mortality of the disease in children and adolescents in the country may be strictly related to socioeconomic indicators, such as gross domestic product per person, the Gini index, poverty rates, per capita income, and the Human Development Index (HDI)[5–6].

It is difficult to estimate the number of children affected by COVID-19 directly or indirectly, since millions of children have suffered some damage during the critical phase of the pandemic, such as hunger, abuse, and threats to vital health services[7]. Although it is a known fact that the incidence in this group is lower, it draws attention to the hidden victims of the pandemic, given that many children around the world, especially in underdeveloped countries, have had their lives altered due to the loss of adult family members, which has impacted reduced income, nutritional deficiency, as well as increased poverty[2,7].

In this context, it should be noted that after the introduction of the COVID-19 vaccine among the adult and aged population, there was a decrease in cases and deaths from the disease in the vaccinated group; however, an increase was observed among children and adolescents, who until then had no access to immunizers[8]. This situation has reinforced the need to expand vaccination coverage for the child and youth public, made available at different times in different countries, and in Brazil, children aged between six months and four years were the last population group to have access to the vaccine[9].

Finally, scientific production on COVID-19 in children and adolescents still has several knowledge gaps, especially concerning understanding how socioeconomic characteristics can influence the distribution of the disease. Therefore, given the endemic nature of the disease, this study aimed to analyze the influence of socioeconomic indicators on the COVID-19 pandemic in the child and youth population.

Methods

This is an ecological study carried out in the five Brazilian regions of the North, Northeast, Midwest, Southeast, and South. The data related to COVID-19 was collected by accessing the Ministry of Health's system, OpenDataSUS[10], and the spreadsheets available on the site were exported in CSV format. Due to the large number of records, these spreadsheets were imported into the R software and manipulated to select the variables of interest and the study period. Socio-economic data were obtained by consulting the official website of the Brazilian Institute of Geography and Statistics[11], where an Excel spreadsheet was previously prepared to tabulate the variables of interest collected by the state.

The population of this study consisted of all reported cases of COVID-19 infection and deaths in children and adolescents, respectively aged 0 to 11 years, 11 months and 29 days, and 12 to 18 years, in all Brazilian municipalities. The period covered data from the registration of the first case of COVID-19 in Brazil on February 25, 2020, until February 25, 2022.

The incidence, mortality, and lethality coefficients of COVID-19 in the population of interest were calculated. The incidence rate was estimated by dividing the number of cases by the number of inhabitants in the age group and period of interest. This was then standardized by multiplying the previous result by 100,000. In this way, it is possible to compare the incidence coefficient per 100,000 inhabitants, which is more frequently reported in other studies. In the same way, the mortality coefficient was calculated, but the number of deaths from the disease was divided by the number of inhabitants in the age group and period of interest, maintaining the same base of 100,000 inhabitants. The lethality rate was calculated as a percentage, dividing the number of deaths by the number of cases multiplied by 100.

Subsequently, the data was analyzed descriptively according to the independent variables HDI, nominal per capita income, and education level of the head of the family, as well as the incidence and mortality of children and young people (dependent variables), both through tables and cartographic representation, using natural break intervals (Jenks). To assess the spatial autocorrelations of the variables of interest, the Global Moran Indices were calculated, both univariate and bivariate. In addition, the formation of clusters was assessed by analyzing the Local Moran's Index, both uni- and bivariate. GeoDa 1.20.0.10 software was used to calculate the indices and QGIS 3.26.0 was used to draw up the maps and frequency distributions[12].

Changes in monthly rates between the years 2020 and 2023 were analyzed using a joinpoint regression model. Based on a Poisson regression, the positions of the change points and regression coefficients were estimated, while the optimal number of joinpoints was selected using a Monte Carlo permutation test, considering a maximum of 6 points. To facilitate interpretation, the monthly percentage changes for each line segment and the corresponding 95% confidence interval were estimated. The data was analyzed using Joinpoint Regression version 4.9.1.0[13]. A significance level of 5% was adopted for all analyses.

The following clusters were considered for bivariate cases: non-significant (regions that did not enter any cluster); High-High (regions with a high frequency of lethality/incidence and a high frequency of the variable of interest); Low-Low (regions with a low frequency of lethality/incidence and a low frequency of the variable of interest); Low-High (regions with a low frequency of the variable of interest and a high frequency of lethality/incidence) and High-Low (regions with a high frequency of the variable of interest and a low frequency of lethality/incidence).

This study did not need to be assessed by the Research Ethics Committee, as the data was obtained from publicly accessible computerized systems.

Results

Brazil registered 46,027 cases and 2,166 deaths from COVID-19 among children aged 0-11 during the study period. However, lethality in the 12 to 18 age group was higher than in children aged 0 to 11. It is noteworthy that the Midwest region had the highest incidence of COVID-19 in the population aged 0 to 18; but, on the other hand, it had the lowest lethality. The Northeast region had the lowest incidence, and the highest lethality and mortality rates were recorded in the North region (Table 1).

We analyzed the presence of change points in the trend pattern of COVID-19 incidence, mortality, and lethality among children and adolescents over the period studied. It is noteworthy that the South region showed one point of change, in the North, there were 6 points of change in the trend of the disease and the other regions did not show significant changes in the trend. Brazil showed 5 points of change in the COVID-19 mortality trend among the child and youth population and 3 points of change in the lethality trend (Table 2).

Table 1 – Number of cases and deaths, incidence, mortality, and lethality from COVID-19 in children and adolescents aged 0 to 18 years (n=55,899,887). São Carlos, SP, Brazil, 2024

Region	No. of cases	No. of deaths	Population	Incidence per 100,000 inhabitants/years	Mortality per 100,000 inhabitants	Lethality per 100 cases
				Rate (95%CI*)	Rate (95%CI)	Rate (95%CI)
North	6,920	485	6,202,116	37.2 (36.3;38.1)	7.8 (7.1;8.5)	7.0 (6.4;7.7)
Northeast	12,801	1,089	16,024,746	26.6 (26.2;27.1)	6.8 (6.4;7.2)	8.5 (8.0;9.0)
Midwest	6,060	251	4,599,088	43.9 (42.8;45.0)	5.5 (4.8;6.2)	4.1(3.6;4.7)
Southeast	25,302	1,086	21,721,467	38.8 (38.4;39.3)	5.0 (4.7;5.3)	4.3 (4.0;4.6)
South	8,087	359	7,352,470	36.7 (35.9;37.5)	4.9 (4.4;5.4)	4.4 (4.0;4.9)
Brazil	59,170	3,270	55,899,887	35.3 (35.0;35.6)	5.8 (5.7;6.1)	5.5 (5.3;5.7)

*CI: Confidence interval

Table 2 – COVID-19 incidence rate, mortality rate, and lethality rate in the population aged 0 to 18 distributed by region (n=55,899,887). São Carlos, SP, Brazil, 2024

Incidence*	Period	MPC† (95% CI‡)	MAPC§ (95% CI)
0 joinpoint			
Brazil	Mar/20 to Feb/23	-0.2 (-2.4;2.0)	-0.2 (-2.4;2.0)
Midwest	Mar/20 to Feb/23	-1.2 (-3.6;1.2)	-1.2 (-3.6;1.2)
Northeast	Mar/20 to Feb/23	-2.0 (-4.3;0.4)	-2.0 (-4.3;0.4)
Southeast	Mar/20 to Feb/23	1.2 (-1.2;3.8)	1.2 (-1.2;3.8)
1 joinpoint			
South	Mar/20 to Jan/22	8.2 (3.2;13.5)	1.4 (-2.3;5.3)
	Jan/22 to Feb/23	-9.0 (-15.0;-2.6)	
6 joinpoints			
North	Mar/20 to May/20	204.3 (-26.5;1.160.1)	-0.4 (-13.9;15.2)
	May /20 to Apr/21	-2.1 (-5.3;1.2)	
	Apr/21 to Out/21	-26.2 (-37.0;-13.5)	
	Out/21 to Jan/22	95.8 (-10.9;330.6)	
	Jan/22 to Apr/22	-48.6 (-75.9;9.8)	
	Apr/22 to Jul/22	63.4 (-41.4;355.7)	
	Jul/22 to Feb/23	-22.7 (-32.8;-11.0)	
Mortality*			
5 joinpoints			
Brazil	Mar/20 to May/20	112.7 (-60.6;1.048.9)	-3.1 (-18.3;15.0)
	May/20 to Oct/20	-23.8 (-43.5;2.7)	
	Oct/20 to Apr/21	27.4 (5.7;53.5)	
	Apr/21 to Oct/21	-32.5 (-46.3;-15.3)	
	Oct/21 to Jan/22	99.8 (-59.9;894.7)	
	Jan/22 to Feb/23	-16.9 (-23.1;-10.2)	
Lethality‖			
5 joinpoints			
Brazil	Mar/20 to Aug/20	-23.5 (-31.0;-15.1)	-5.2 (-8.3;-1.9)
	Aug/20 to Mar/21	8.2 (0.3;16.7)	
	Mar/21 to Jun/21	-10.9 (-34.7;21.7)	
	Jun/21 to Feb/23	-3.5 (-5.3;-1.7)	

*100,000 inhabitants/year; †MPC: Monthly percentage change; ‡CI95%: 95% confidence interval; §MAPC: Mean monthly percentage change; ‖per 100 cases

When calculating Moran's Index, the results showed a relationship between the mortality coefficient and per capita income, HDI, and schooling, that is, the higher the indices of these socioeconomic variables, the lower the mortality coefficients among the population aged 0 to 18. The negative correlation shows that mortality from COVID-19 in children and adolescents aged 0 to 18 was lower in states with a higher HDI, higher per capita income, and/or higher schooling of the head of household (Table 3).

Table 3 – Moran's index for COVID-19 incidence and mortality in the population aged 0 to 18 (n=55,899,887). São Carlos, SP, Brazil, 2024

Variables	Moran's Index	p-value*
Incidence †		
Per capita income	0.049	0.294
Human development index	0.041	0.329
Schooling (completed high school or more)	0.015	0.382
Mortality†		
Per capita income	-0.302	0.003
Human development index	-0.329	0.003
Schooling (completed high school or more)	-0.178	0.048

*p>0.05 Concordance Moran's index; †100,000 inhabitants/year

Bivariate spatial autocorrelations between epidemiological variables and economic and schooling variables were also analyzed. When correlating the incidence coefficient of adolescents aged 12 to 18 with nominal monthly household income per capita in Brazilian reals, the state of Piauí stood out as having a Low-Low cluster, which means, a low frequency of incidence and monthly income, while the state of Mato Grosso do Sul had a High-High cluster, with a high frequency of both variables (Figure 1A). In the analysis of the correlation between the mortality coefficient and the education level of the head of the family, Minas Gerais showed a Low-Low cluster, with a low mortality rate and low education level (Figure 1C).

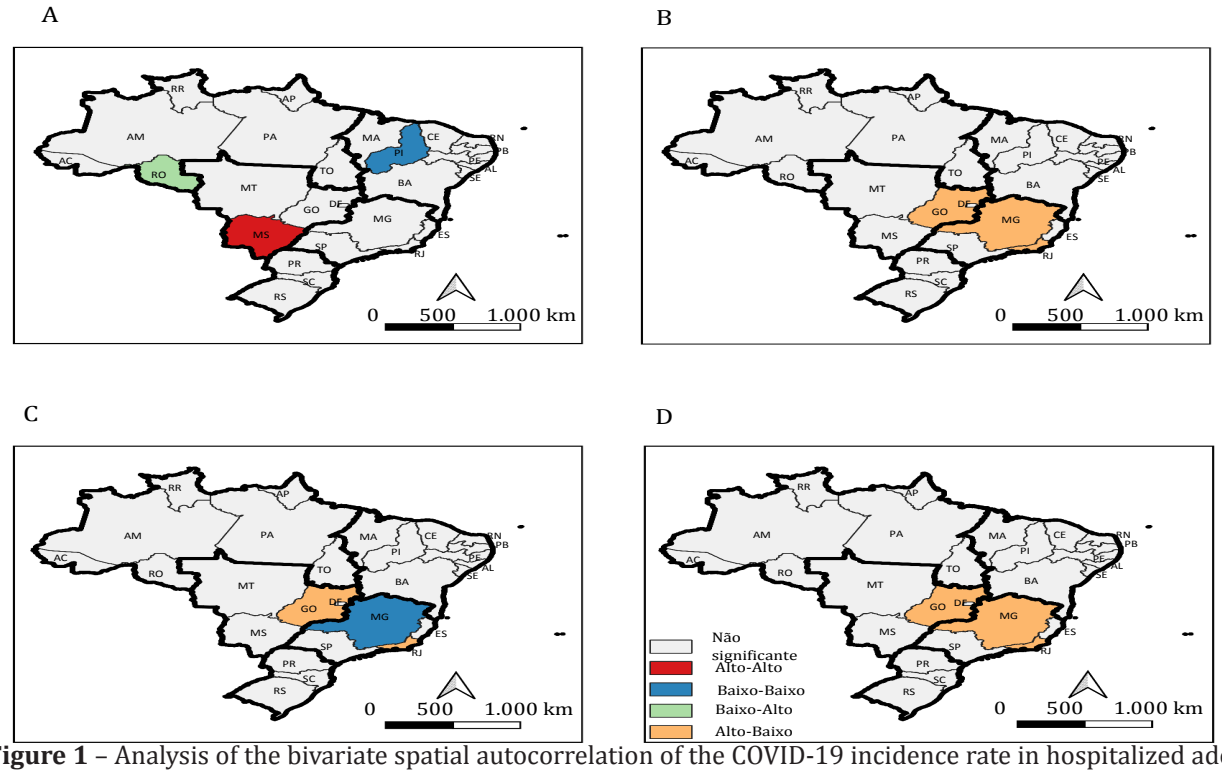

Figure 1 – Analysis of the bivariate spatial autocorrelation of the COVID-19 incidence rate in hospitalized adolescents aged 12 to 18 with nominal monthly household income per capita (n=55,899,887). São Carlos, SP, Brazil, 2024

All Brazilian regions showed a significant difference in the incidence of COVID-19 in the study population, with a higher incidence among children aged 0 to 11; about mortality, the Southern region showed a significant difference in mortality among adolescents aged 12 to 18 and the Northeastern region in the population aged 0 to 11; however, lethality was higher in adolescents in all Brazilian regions, but there was no significant difference between age groups in the Midwest region (Table 4).

Table 4 – COVID-19 incidence, mortality, and lethality coefficients in the 0-11 and 12-18 age groups and differences between them (n=55,899,887). São Carlos, SP, Brazil, 2024

Description/Region	0 to 11 years	12 to 18 years	Differences between rates	p-value‡
	Rate (95% CI*)	Rate (95% CI)	(p.p) † (95% CI)	
Incidence §				
North	45.0 (43.8;46.3)	24.2 (23.0;25.3)	20.8 (19.2;22.5)	<0.010
Northeast	34.3 (33.6;34.9)	14.5 (13.9;15.0)	19.8 (18.9;20.6)	<0.010
Southeast	49.1 (48.5;49.8)	20.9 (20.3;21.5)	28.2 (27.3;29.1)	<0.010
South	43.1 (42.0;44.1)	25.3 (24.2;26.4)	17.8 (16.2;19.3)	<0.010
Midwest	48.6 (47.1;50.1)	35.7 (34.1;37.4)	12.9 (10.7;15.1)	<0.010
Brazil	43.7 (43.3;44.1)	21.1 (20.8;21.5)	22.6 (22.0;23.1)	<0.010
Mortality §				
North	8.3 (7.4;9.2)	7.1 (6.0;8.1)	1.2 (-0.2;2.6)	0.090
Northeast	8.0 (7.5;8.6)	4.8 (4.3;5.4)	3.2 (2.4;4.0)	<0.010
Southeast	5.0 (4.7;5.4)	5.0 (4.5;5.4)	0.1 (-0.5;0.7)	0.820
South	4.1 (3.6;4.7)	6.2 (5.3;7.2)	-2.1 (-3.2;-1.0)	<0.010
Midwest	5.7 (4.8;6.6)	5.0 (4.0;6.1)	0.7 (-0.7;2.0)	0.180
Brazil	6.2 (5.9;6.4)	5.3 (5.0;5.6)	0.8 (0.4;1.2)	<0.010
Lethality ‖				
North	6.1 (5.5;6.8)	9.7 (8.2;11.2)	-3.6 (-5.2;-2.0)	<0.010
Northeast	7.8 (7.3;8.4)	11.1 (9.8;12.4)	-3.3 (-4.6;-1.9)	<0.010
Southeast	3.4 (3.2;3.7)	7.9 (7.1;8.7)	-4.5 (-5.3;-3.7)	<0.010
South	3.2 (2.8;3.7)	8.2 (6.9;9.4)	-5.0 (-6.3;-3.6)	<0.010
Midwest	3.9 (3.3;4.5)	4.7 (3.7;5.7)	-0.8 (-2.0;0.4)	0.180
Brazil	4.7 (4.5;4.9)	8.4 (7.9;8.9)	-3.7 (-4.2;-3.2)	<0.010

*CI: Confidence interval; †p.p: Percentage points; ‡p>0.05 Concordance in rates; §100,000 inhabitants/year; ‖per 100 cases

Discussion

This analysis pointed to the highest COVID-19 incidence rate in the child and youth population in the Midwest region, while the highest mortality rate was found in the North region and the highest lethality in the Northeast region. This study showed that in Brazil, COVID-19 mortality in the study population showed points of change in the trend during the period analyzed and in regions with a higher HDI, higher per capita income, and/or higher schooling of the head of the family; COVID-19 mortality in children and adolescents was lower.

It should be noted that SARS-CoV-2 can infect all age groups, however, generally, children and adolescents are asymptomatic or manifest the disease in its mildest form, this part of the population can evolve into severe cases requiring hospitalization, as well as resulting in death. Concerning the risk factors for worsening COVID-19, as well as those observed in other age groups, the presence of comorbidities has a major influence on the outcome of the infectious disease[14].

Although the highest number of cases and deaths was observed in children, COVID-19 lethality was higher in adolescents. One of the hypotheses that the literature points to is the greater expression of Angiotensin Converting Enzyme 2 (ACE2) in adolescents compared to children, with ACE2 being the receptor to which SARS-CoV-2 attaches, through binding by the S protein, to enter cells and initiate viral replication[15].

Other explanations for the development of milder forms of COVID-19 infection in children could be related to a more robust immune response and the high regenerative capacity of the alveolar epithelium, which gradually loses its regenerative potential as it ages. In addition, many of the comorbidities often associated with COVID-19 mortality are not generally observed in the child and youth population, which makes them less susceptible to severe forms of infection when compared to other age groups, such as adults and the aged[16].

However, in addition to the intrinsic factors that can influence the incidence, mortality, and lethality of COVID-19 in the child and youth population, it should be noted that the pandemic has gone through several phases, from the absence of recognized treatments for the disease, the emergence of variants with greater potential for pathogenicity and transmissibility, to the development of vaccines against the disease and the respective implementation of vaccination campaigns around the world[9,17]. These factors certainly had an impact on the outcome of the disease and explain the changes during the pandemic in the incidence and mortality coefficients in the child and youth population, as well as in the general population.

Furthermore, differences in the incidence and mortality coefficients in the child and youth population may be related to regional adherence to non-pharmacological measures to combat COVID-19; countries, states, and municipalities have implemented and made measures to combat the virus more flexible at different times, due to the influence of the pandemic scenario in each location, as well as political and ideological issues[18].

In this regard, in Brazil, some political leaders have adopted a denialist stance regarding the seriousness of the pandemic, resulting in disagreements regarding the implementation of virus control measures, especially those related to physical isolation and individual prevention: such as the use of masks, in addition to the lack of investment in mass testing, measures scientifically recognized for their efficiency in preventing the disease[19].

In this scenario, an analysis showed that during the first year of the pandemic, in mid-August 2020, the adoption of measures to combat the virus by region was different, showing that measures to reduce agglomerations, were widely adopted by municipalities in the South Regions; in the Northeast region, it was a medium adherence and a low adherence in the North region[20].

In addition, apart from the differences in the implementation of measures to combat the virus, the association with other territorial and socio-economic factors in each region could explain the differences observed in the incidence, mortality, and lethality coefficients in the child and youth population in Brazil. Corroborating the findings of this study, which showed that most cases and deaths in the child and adolescent population were recorded in the North and Northeast regions, another analysis showed that children living in these regions were 3.4 times more likely to die from COVID-19 than those living in other Brazilian regions[21].

When analyzing the influence of socioeconomic factors in the different regions of Brazil, it should be noted that all the states in the Northeast have unfavorable socioeconomic indicators, with the state of Maranhão having the worst indicators, with the second worst HDI, the lowest monthly household income per capita and the highest percentage of population below the poverty line and in extreme poverty[22].

It is undeniable that the effects of poverty on children's health even precede their birth, i.e. socio-economic inequalities can influence the health of pregnant women, health care, and prenatal care, con-

sequently resulting in premature births, low birth weight, health problems in newborns, and developmental disabilities. In addition, poverty is associated with inadequate child and family nutrition, food insecurity, and a lack of adequate health care[23]. Thus, a weakened immune system or the presence of pre-existing diseases, in any age group, can influence the body's ineffective coping with SARS-CoV-2 infection, which can result in the disease progressing to severe forms of infection and even death[14].

Many of the intrinsic risk factors observed in children and adolescents may be consequences of the external factors to which they have been exposed throughout their lives, which makes us reflect on the importance of socioeconomic conditions in coping with the pandemic in different regions; a large portion of the child and youth population was in situations of socioeconomic disadvantage, and even difficulties in accessing health services[23].

In the meantime, the findings of this study indicate that COVID-19 mortality in children and adolescents was lower in states with a higher HDI; on the other hand, studies in other countries have shown divergent results. Another global analysis showed that in countries with a population of 10 million or more, there was a significant positive correlation between the HDI, the incidence and mortality coefficients, and the COVID-19 tests carried out, i.e. the higher the HDI, the higher the cumulative incidence coefficients of cases, deaths and tests carried out[24].

It is understood that the increase in COVID-19 incidence and mortality coefficients in countries with a higher HDI may be related to easier access to health services, implying greater diagnosis of the disease, notification, monitoring, and referral. Thus, localities with a low HDI could have low testing and underreporting of the disease compared to countries with a high HDI. Furthermore, it should be noted that in Brazil, there has been low testing among the child and youth population, since most of them are asymptomatic or have mild symptoms that can be confused with other diseases[24-25].

Another component of the HDI that appears to be closely associated with COVID-19 outcomes refers to education, showing that the level of schooling can influence coping with health emergencies. In this scenario, in Peru, it was observed that the high coefficients of mortality from SARS-CoV-2 in all age groups were associated with a low level of education[26].

Thus, it is understood that a higher level of education can provide a cognitive advantage, which could help discern between scientific information and false information conveyed in the media; this may have had an impact on adherence to preventive measures to deal with the pandemic, such as social isolation and individual prevention measures such as wearing a mask and hand hygiene[27-28]. That said, the level of education of those responsible for the care of children and adolescents can influence the health of this population group, since encouraging adherence to preventive measures against contagion with the virus, as well as vaccination against COVID-19, are direct responsibilities of those responsible for children.

In addition, the level of family education can influence the type of occupation and consequently family income. Family income has had a direct impact on people's ability to cope with the health emergency caused by COVID-19. However, in Brazil, there has been a long delay in implementing actions aimed at social aid, which is essential given the country's regional socio-economic inequalities[19]. It should also be noted that many jobs during the pandemic did not allow for home office work, exposing these workers to a greater risk of contracting the disease and acting as carriers of the virus in their homes, infecting children and adolescents.

However, in addition to regional inequalities, children and adolescents experienced another setback after the start of the COVID-19 immunization campaigns. Although vaccination began in mid-January 2021, it wasn't until June 11, 2021, that vaccination was authorized for children aged twelve and over, and it wasn't until December of the same year that it was extended to children aged six months to under five[9].

However, in mid-August 2022, approximately one year after the authorization for vaccination in the child and youth population, an analysis described the low adherence to vaccination in the country, pointing out that only 52% of children aged 5 to 11 and 72% of adolescents aged 12 to 17 were fully vaccinated against COVID-19. The highest rates of vaccination against the disease in children and adolescents occurred in municipalities in the Southeast and South regions, while the lowest rates were observed in municipalities in the North and Northeast regions[29].

Although vaccination is the most cost-effective health measure for diseases in the world, there has been hesitancy in adherence to vaccination in the child and youth population. Among the factors related to vaccine hesitancy are a lack of awareness of the risk of contracting immunepreventable diseases, the influence of religious and political leaders, belief in conspiracy theories, fear of vaccine side effects, the emergence of the anti-vaccine movement, the spread of fake news and difficulty in accessing health services. These factors can contribute to the return of diseases considered extinct in the country, as well as to the worsening of the COVID-19 disease[30].

Thus, several factors may be related to incidence and mortality in the child and youth population during the pandemic, such as hesitancy to vaccinate against COVID-19, which prevents severe forms of the disease, regional socioeconomic vulnerabilities that impact access to preventive measures for the disease as well as access to health services. These factors can result in distinctions observed in the different regions of the country, reflecting the regional inequalities present in the Brazilian territory.

Study limitations

This study has some limitations, such as the possibility of underreporting of COVID-19 in children and adolescents and the use of secondary data from Health Information Systems, which may present incomplete information in some records.

Contributions to practice

However, this analysis has helped to highlight the influence of socioeconomic indicators on the incidence, mortality, and lethality of COVID-19 in the child and youth population in the different regions of Brazil, showing that regions with better socioeconomic variables tend to have lower incidence and mortality from the disease in the study population. In this way, knowledge of regional socioeconomic inequalities helps the public health sector in planning actions and establishing strategies aimed at reducing preventable deaths, as well as supporting the implementation of public policies aimed at minimizing socioeconomic and health inequalities in the country.

Conclusion

In this analysis, it was possible to observe that the incidence, mortality, and lethality of COVID-19 showed variability in the different regions of Brazil, indicating the highest incidence coefficient in the child and youth population in the Midwest region, while the highest mortality rate was found in the North region and the highest lethality in the Northeast region.

Finally, the results of this study showed that the incidence, mortality, and lethality of COVID-19, especially in the child and youth population, goes far beyond the immunological conditions of individuals, revealing the strong influence of socio-economic indicators related to HDI, nominal per capita income and education of the head of the family on health indicators.

Acknowledgments

To the Foundation for Research Support of the State of São Paulo (Fundação de Amparo à Pesquisa do Estado de São Paulo) - Process: 2022/07051-9 and to the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior).

Authors' contribution

Conception and design or analysis and interpretation of data; writing of the manuscript or relevant critical review of the intellectual content; final approval of the version to be published; responsibility for all aspects of the text in ensuring the accuracy and integrity of any part of the manuscript: Ribeiro AC, Falciroli IMV, Cano RN, Uehara SCSA.

References

1. Chiotos K, Fitzgerald JC. COVID-19 in children-learning from the past, planning for the future. JAMA Pediatr. 2023;177(9):885-7. doi: https://doi.org/10.1001/jamapediatrics.2023.2354
2. Oliveira EA, Colosimo EA, Silva ACS, Mak RH, Martelli DB, Silva LR, et al. Clinical characteristics and risk factors for death among hospitalised children and adolescents with COVID-19 in Brazil: an analysis of a nationwide database. Lancet Child Adolesc Health. 2021;5(8):559-68. doi: https://doi.org/10.1016/S2352-4642(21)00134-6
3. Flaxman S, Whittaker C, Semenova E, Rashid T, Parks RM, Blenkinsop A, et al. Assessment of COVID-19 as the underlying cause of death among children and young people aged 0 to 19 years in the US. JAMA Netw Open. 2023;6(1):e2253590. doi: https://doi.org/10.1001/jamanetworkopen.2022.53590
4. Bhopal SS, Bagaria J, Olabi B, Bhopal R. Children and young people remain at low risk of COVID-19 mortality. Lancet Child Adolesc Health. 2021;5(5):e12-e13. doi: https://dx.doi.org/10.1016/s2352-4642(21)00066-3
5. Santos AAL, Silva JP, Silva TCL, Souza TA, Miranda FAN, Torres GV. Influence of social indicators on the occurrence and mortality of COVID-19 in Brazil in June 2020. Saúde Pesq. 2022;15(1):e-9559. doi: https://doi.org/10.17765/2176-9206.2022v15n1.e9559
6. Fabrin C, Boing AC, Garcia LP, Boing AF. Socioeconomic inequality in hospital case fatality rate and care among children and adolescents hospitalized for COVID-19 in Brazil. Rev Bras Epidemiol. 2023;26:e230015. doi: https://dx.doi.org/10.1590/1980-549720230015
7. Ahmed S, Mvalo T, Akech S, Agweyu A, Baker K, Bar-Zeev N, et al. Protecting children in low-income and middle-income countries from COVID-19. BMJ Glob Health. 2020;5(5):e002844. doi: https://doi.org/10.1136/bmjgh-2020-002844
8. Orellana JDY, Marrero L, Horta BL. Mortalidade por COVID-19 no Brasil em distintos grupos etários: diferenciais entre taxas extremas de 2021 e 2022. Cad Saúde Pública. 2022;38(7):e00041922. doi: https://doi.org/10.1590/0102-311XPT041922
9. Lima EJF, Leite RD. COVID-19 vaccination in children: a public health priority. J Pediatr (Rio J). 2023;99(Suppl 1):28-36. doi: https://dx.doi.org/10.1016/j.jped.2022.11.006
10. Ministério da saúde (BR). OpenDataSUS. SRAG 2020 - Banco de dados de síndrome respiratória aguda grave - incluindo dados da COVID-19 [Internet]. 2023 [cited Jan 30, 2024]. Available from: https://opendatasus.saude.gov.br/dataset/srag-2020/resource/06c835a6-cf33-448a-aeb1-9dbc34065fea
11. Instituto Brasileiro de Geografia e Estatística (IBGE). Áreas territoriais [Internet]. 2021 [cited Jan 30, 2024]. Available from: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/15761-areas-dos-municipios.html?=&t=acesso-ao-produto
12. Anselin L, Ibnu S, Youngihn K. GeoDa: An introduction to spatial data analysis. Geogr Anal. 2006;38(1):5-22. doi: https://doi.org/10.1111/j.0016-7363.2005.00671.x
13. Liu B, Kim HJ, Feuer EJ, Graubard BI. Joinpoint regression methods of aggregate outcomes for complex survey data. J Surv Stat Methodol. 2023;11(4):967-89. doi: http://doi.org/10.1093/jssam/smac014
14. Mercolini F, Cesaro S. COVID-19 in children and adolescents: Characteristics and specificities in immunocompetent and oncohematological patients. Mediterr J Hematol Infect Dis. 2022;14(1):e2022009. doi: http://dx.doi.org/10.4084/mjhid.2022.009
15. Williams PCM, Howard-Jones AR, Hsu P, Palasanthiran P, Gray PE, McMullan BJ, et al. SARS-CoV-2 in children: spectrum of disease, transmission and immunopathological underpinnings. Pathology. 2020;52(7):801-8. doi: https://dx.doi.org/10.1016/j.pathol.2020.08.001

16. Dhochak N, Singhal T, Kabra SK, Lodha R. Pathophysiology of COVID-19: why children fare better than adults? Indian J Pediatr. 2020;87(7):537-46. doi:https://dx.doi.org/10.1007/s12098-020-03322-y

17. Michelon CM. Principais variantes do SARS-CoV-2 notificadas no Brasil. Rev Bras Anal Clin. 2021;53(2):109-16. doi: https://dx.doi.org/10.21877/2448-3877.202100961

18. Shimizu HE, Lima LD, Carvalho ALB, Brígida Carvalho BG, D'Ávila Viana AL. Regionalization and the federative crisis in the context of the Covid-19 pandemic: deadlocks and perspectives. Saúde Debate. 2021;45(131):945-57. doi: https://dx.doi.org/10.1590/0103-1104202113101I

19. Castilho M, Pero V, Razafindrakoto M, Roubaud F, Saboia J. Negacionismo e o papel dos fatores políticos para a mortalidade por Covid-19 no Brasil. Nova Econ. 2023;33(1):65-93. doi: https://doi.org/10.1590/0103-6351/7528

20. Lui L, Albert CE, Santos RM, Vieira LC. Disparidades e heterogeneidades das medidas adotadas pelos municípios brasileiros no enfrentamento à pandemia de Covid-19. Trab Educ Saúde. 2021;19:e00319151. doi: https://doi.org/10.1590/1981-7746-sol00319

21. Sousa BLA, Silva CA, Ferraro AA. An update on the epidemiology of pediatric COVID-19 in Brazil. Rev Paul Pediatr. 2022;40:e2021367. doi: https://doi.org/10.1590/1984-0462/2022/40/2021367

22. Kerr L, Kendall C, Silva AAM, Aquino EML, Pescarini J, Almeida RLF, et al. COVID-19 in Northeast Brazil: achievements and limitations in the responses of the state governments. Ciênc Saúde Coletiva. 2020;25(2):4099-120. doi: https://doi.org/10.1590/1413-812320202510.2.28642020

23. Royce JB. The effects of poverty on childhood development. J Ment Health Soc Behav. 2021;3(1):132. doi: https://doi.org/10.33790/jmhsb110032

24. Mirahmadizadeh A, Ghelichi-Ghojogh M, Vali M, Jokari K, Ghaem H, Hemmati A, et al. Correlation between human development index and its components with COVID-19 indices: a global level ecologic study. BMC Public Health. 2022;22(1):1549. doi: http://dx.doi.org/10.1186/s12889-022-13698-5

25. Liu K, He M, Zhuang Z, He D, Li H. Unexpected positive correlation between human development index and risk of infections and deaths of COVID-19 in Italy. One Health. 2020;10:100174. doi: https://doi.org/10.1016/j.onehlt.2020.100174

26. Concepción-Zavaleta MJ, Coronado-Arroyo JC, Zavaleta-Gutiérrez FE, Concepción-Urteaga LA. Does level of education influence mortality of SARS-CoV-2 in a developing country? Int J Epidemiol. 2021;49(6):2091-93. doi: https://dx.doi.org/10.1093/ije/dyaa193

27. Miguez FGG, Oliveira G, Enriquez-Martinez OG, Fonseca MJMD, Griep RH, Barreto SM, et al. Fatores associados à adesão a comportamentos preventivos da COVID-19 em participantes do ELSA-Brasil. Cad Saúde Pública. 2023;39(8):e00188322. doi: https://doi.org/10.1590/0102-311xpt188322

28. Majam M, Fischer A, Phiri J, Venter F, Lalla-Edward ST. International citizen project to assess early stage adherence to public health measures for COVID-19 in South Africa. PLoS One. 2021;16(3):e0248055. doi: https://dx.doi.org/10.1371/journal.pone.0248055

29. Santos VS, Siqueira TS, Silva JRS, Gurgel RQ. Spatial clustering of low rates of COVID-19 vaccination among children and adolescents and their relationship with social determinants of health in Brazil: a nationwide population-based ecological study. Public Health. 2023;214:38-41. doi: https://doi.org/10.1016/j.puhe.2022.10.024

30. Silva GM, Sousa AAR, Almeida SMC, Sá IC, Barros FR, Sousa Filho JES, et al. COVID-19 vaccination challenges: from fake news to vaccine hesitancy. Ciênc Saúde Coletiva. 2023;28(3):739-48. doi: https://dx.doi.org/10.1590/1413-81232023283.09862022EN