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High blood pressure and associated factors in adolescent students

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Abstract

The literature has registered a growing percentage of adolescents with arterial hypertension. This study aimed to analyze the prevalence of high blood pressure (HBP) and identify associated factors among adolescent students. This is a cross-sectional study, with a representative sample of adolescents from public schools in the north of Minas Gerais. Validated instruments covering demographic factors, eating habits and physical activity were used. In addition to blood pressure, data on cardiorespiratory fitness and measurements of visceral fat, overall fat percentage, and body mass index - BMI were collected. After bivariate analysis, the associated variables up to the level of 20% ($p \leq 0.20$) were analyzed using logistic regression, assuming a significance level of 5% for the final model. 880 adolescents participated in the study, with a slight predominance of females. The prevalence of HBP was 16.9%. The variables shown to be associated with HBP, after logistic regression analysis, were: high BMI (OR=1.96; 95%CI=1.32-2.89) and male gender (OR=1.45; 95%CI =1.01-2.07). No behavioral or physical fitness-related variables were associated. HBP has a high prevalence among adolescent students and is associated with being overweight and being male.

Keywords: Arterial Hypertension. Adolescent. Risk factors. Obesity. Physical aptitude.

INTRODUCTION

The Brazilian Society of Cardiology (SBC) defines systemic arterial hypertension (SAH) as a multifactorial clinical condition, characterized by the persistence of high and sustained blood pressure levels, often associated with metabolic and hormonal changes and trophic phenomena (cardiac and vascular hypertrophy)[1]. In adults, SAH is one of the most important preventable risk factors for premature death, mainly due to coronary artery disease. The World Health Organization (WHO) estimates that approximately one billion people have arterial hypertension worldwide, with high mortality each year[2].

The development of SAH is related to several factors throughout life. Among these factors, obesity, lack of physical activity, sedentary behavior, inadequate eating habits, dyslipidemia, insulin resistance, and low birth weight stand out[3-8]. The adolescent population, considering the modern lifestyle, is particularly exposed to several of these risk

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factors, mainly due to dietary inadequacies, overweight, and obesity. These conditions can lead to complications in adulthood, especially in relation to arterial hypertension, dyslipidemia, insulin resistance, and type II diabetes[9]. The importance of studies in the young population is justified by the possibility of avoiding cardiovascular complications and consequent comorbidities in adult life[10].

There is evidence that the onset of SAH in adults occurs in childhood and adolescence[11]. There are few studies in Brazil that assess the prevalence of SAH in childhood and adolescence[3,12]. Most of the studies are local or regional and demonstrate a great variability of results, which may be due to different methodologies employed or different cutoff points assumed in each study, but also to regional particularities of the evaluated population[12].

The environment experienced during childhood seems to be strongly related to the risk of noncommunicable diseases in adult life. The stimuli that occur in childhood and adolescence provoke permanent adaptation responses, which produce long-term changes in tissue structures or functions, which can lead to left ventricular hypertrophy, glomerular injury, thickening of the intima layer of vessels, and neuronal damage that would affect cognition, as well as being considered predisposing factors for vascular accidents and atherosclerosis[1,13]. Early intervention in the child's lifestyle is capable of ensuring a healthy lifestyle for the circulatory system in adult life and reducing cardiovascular morbidity and mortality rates. This fact justifies research on risk factors for chronic diseases even among young people[8,14].

The difficulties in carrying out studies at a national level, and the need for knowing blood pressure levels and factors related to SAH among adolescents, led to the realization of a local study, with a population with specific characteristics as a way of identifying the distribution of High Blood Pressure (HBP), a strong predictor of SAH. Moreover, this study can evaluate its associations with demographic, behavioral, dietary, and physical activity factors, in addition to physical fitness, an aspect not yet addressed in the national literature. The objective of this present study was, therefore, to analyze the prevalence of HBP and identify associated factors among adolescents from public schools in a city in the north of Minas Gerais.

METHODOLOGY

This is a cross-sectional and analytical study, carried out in Montes Claros, in the north of Minas Gerais. The city has approximately 400,000 inhabitants and is the main urban center in the region. The target population of the study consisted of students from public schools in the urban area of the city. The sample selection was of the cluster probabilistic type in two stages. In the first stage, schools were randomly selected with a selection proportional to size. In the second stage, the selection of classes was carried out by simple random sampling, involving all students from the selected classes.

The sample calculation was performed based on the following parameters: a confidence level of 95%, an estimated prevalence of 18%, considering a similar previous study[15], and a sampling error of 3.5%. The number defined by the sample calculation was multiplied by a correction factor for the design effect (deff) equal to two, and an increase of

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10% was estimated for the non-response rate, which determined a minimum sample size of 874 adolescents.

Adolescents regularly enrolled in middle or high school, of both sexes, aged less than 18 years were included in the study. Students with debilitating chronic diseases, those with genetic syndromes and hypothyroidism, those who were in chronic use of corticosteroids (according to statements by the students themselves, parents, or teachers) were excluded, and those who were absent from the classroom on days were considered as losses to data collection.

For data collection, a self-administered questionnaire prepared by the authors was used, which included sociodemographic characteristics, food consumption, lifestyle habits, and physical activity, and physical assessments of the students were carried out including physical fitness tests and measurement of anthropometric data.

Questions about food consumption were objective questions to assess eating habits, considering the consumption of some specific foods, fruits, vegetables and legumes. The construction of the questionnaire was adapted and based on the National School Health Survey[16]. Food intake was measured using a questionnaire, in which the number of days, in the week preceding the study, on which the student consumed: vegetables, raw or cooked; fresh fruit or fruit salad; junk food (sweets, candies, lollipops, chocolates, or bonbons). In this instrument, the structure of the question was: "In the last 7 days, how many days did you eat (food)?", and the answer options were: "I did not eat (food) in the last seven days", "1 day in the last seven days", "2 days in the last seven days", "3 days in the last seven days", "4 days in the last seven days", "5 days in the last seven days", "6 days in the last seven days", and " every day for the past seven days." A response equal to or greater than five days a week was considered regular consumption of the food in question. Sedentary behavior was assessed by screen time (television, computer, tablets, and the like), assuming a time equal to or greater than two hours a day is undesirable[17].

Weight was measured in the morning, using a portable digital electronic scale from Omron (HBF514C, Tokyo, Japan), with a capacity of up to 150kg and sensitivity of 100g. Adolescents were weighed wearing light clothing and barefoot, positioned with arms relaxed along the body. They were asked to remove shoes, earrings, rings, watches, and metallic objects and to urinate at least 30 minutes before the measurement.

Height was assessed using a portable stadiometer, with a scale from 35.0 to 213.0 cm and a precision of 0.1 cm. For this measurement, the adolescents were instructed to keep their feet together, centered on the equipment, with their heads, buttocks and heels touching the wall in a horizontal plane. The stadiometer ruler was then moved to the adolescent's head, and the reading was then performed after a normal expiration.

BMI was calculated by dividing weight in kg by height in meters squared (kg/m^2). From the results obtained, the classification of accentuated thinness, thinness, eutrophic, overweight, or obese was adopted based on the Z-Score criteria, established by the WHO, according to age and gender. For data analysis, the variable was dichotomized into "overweight" (overweight and obese) and "not overweight" (accentuated thinness, thinness, and eutrophic).

Visceral fat was estimated using the waist-to-height ratio (WHR). WHR was calculated using the ratio of waist circumference (WC) in centimeters (cm) and height (cm). WC assessment was performed using an inelastic millimetric tape, that was 150.0cm long (Cardiomed®, Brazil), with the umbilicus as the reference, for

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three repeated measurements. WHR was considered adequate (healthy zone) when it was less than 0.5, values above this were considered at risk of central adiposity (risk zone)[18].

The general body fat measurement was performed by means of skinfold measurements, following the protocol recommended by the Esporte Brasil project (PROESF-BR)[19]. The reading was taken to the nearest millimeter, in about 2 to 3 seconds. The procedure was repeated three times, using the mean value of the measurements. The following folds were measured: pectoral; axillary; triceps; suprailiac; biceps; subscapular; abdomen; and calf through the AVA NUTRI series 110501-17 adipometer. The calculation of body fat percentage (BF%) was performed using the equation proposed by Slaughter *et al.*[20].

Health-Related Physical Fitness (HRPF) was measured based on cardiorespiratory endurance through the six-minute run/walk test, following the standards used by PROESP-BR[19]. The test was carried out in the courtyards of the schools with prior marking of their perimeters. The students were divided into groups of four because it was an adequate amount for the dimensions of the track marked on the court and informed about the execution of the test, emphasizing the fact that they should run as long as possible, avoiding speed spikes interspersed with long walks. During the test, the students were informed of the passage of time at two, four, and five minutes. After completing six minutes of testing, a sound signal with a whistle interrupted the race and they remained in the place where they stopped until the distance covered was recorded, written down in meters with a place after the decimal point. Cutoff points are defined considering the distance covered for each age and sex.

Blood pressure (BP) measurement was performed using a calibrated digital sphygmomanometer (Model HEM-CR24®, OMRON®), with measurement carried out according to the Protocol of the VII Brazilian Guideline on Arterial Hypertension, with the teens sitting, legs uncrossed, feet supported on the floor, back leaning on the chair, and relaxed, with the arm at heart level, supported, with the palm of the hand facing upwards and their clothes without throttling the limb. Elevated blood pressure values were those above the 95^{th} percentile for age, sex, and height of the examined student[1].

The data collection team was selected among university students in the health area (nursing, medicine, and physical education) and was specially trained for the interview and for data collection. As a way to standardize the performance of the interviewers, a pilot study was carried out in a school with similar characteristics to the other selected schools and helped to define the order of data collection. Data from the pilot study were not used in this research.

The collected data were entered and evaluated using the Statistical Package for Social Sciences (SPSS) version 21.0 software. The complex sampling plan was considered for the statistical analysis of the data, and each adolescent was associated with a weight (w), which corresponded to the inverse of their probability of inclusion in the sample (f). Bivariate analyses were carried out between the characteristics of the group and the presence of HBP using the chi-square test, and the variables that were associated up to the 20% level ($p \leq 0.20$) were included in the multiple analysis of logistic regression binary, which allowed for the definition of Odds Ratio (OR) and their respective 95% confidence intervals (95%CI). In the final model, only variables with a descriptive level of up to 5% ($p< 0.05$) were considered.

All ethical aspects were respected. Participants signed an assent term and parents or

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guardians signed an informed consent form. The institutions involved also authorized the research. The study project was approved by the Ethics and Research Committee of the State University of Montes Claros (Opinion nº 1.908.982).

RESULTS

A total of 880 adolescents aged 11 to 17 years old were evaluated, 458 (52.0%) of whom were female. High blood pressure (LBP) was found in 16.9% (n=149) of the adolescents. As for health-related behaviors, it was highlighted that almost half of the adolescents had a high regular consumption of sweets and junk food (49.8%). Regular consumption of fruits and vegetables was recorded for just over half of the group (51.9%). Regarding screen time, 17.0% of students (n=147) reported two or more hours (Table 1).

Regarding the HRPF, only 6.9% of the students (n=50) had cardiorespiratory fitness values in the healthy zone. Overweight was recorded for 22.2% of the adolescents (n=193) and the general percentage of fat was in the risk zone for 490 of them (44.6%) (Table 1).

Table 2 presents the results of the bivariate analyses. Variables with significant associations up to the 20% level (p<0.20) were jointly evaluated using binary logistic regression. The variables gender (p=0.059), regular consumption of sweets (p=0.070), screen time (p=0.054), BMI (p=0.002), and overall fat percentage (p=0.104) were associated with HBP and were selected to compose the multiple models.

The variables that remained statistically associated with HBP after logistic regression analysis were male gender (OR=1.45; 95%CI:1.01-2.07) and overweight (OR=1.96; 95%CI:1.32-2.89) (Table 3).

Table 1 – Demographic characterization, health-related behaviors and health-related physical fitness of adolescents from public schools (n=880). Montes Claros, MG, Brazil, 2017.

Characteristics	n	%
Demographics		
Age Group		
11 to 12 years	343	39.0
13 to 14 years old	456	51.8
15 to 17 years old	81	9.2
Sex		
Female	458	52.0
Male	422	48.0
Health-Related Behaviors		
Regular consumption of greens and vegetables		
No	462	48.1
Yes	418	51.9
Regular fruit consumption		
No	543	61.9
Yes	337	38.1

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...continuation table 1

Characteristics	n	%
Regular consumption of junk food and sweets		
No	441	50.2
Yes	439	49.8
Screen Time (PC/TV)		
≥ 2 hours	147	17.0
< 2 hours	733	83.0
Health-Related Physical Fitness		
Cardiorespiratory Fitness		
Risk Zone	830	93.1
Healthy zone	50	6.9
BMI		
Overweight/Obesity	193	22.2
Thinness/Eutrophy	687	77.8
Visceral Fat		
Risk Zone	58	6.8
Healthy zone	822	93.2
Overall Fat Percentage		
Risk Zone	490	44.6
Healthy zone	390	55.4

Table 2 – Bivariate analyses to verify the factors associated with high blood pressure in adolescents from public schools (n=880). Montes Claros, MG, Brazil, 2017.

Variables	High Blood Pressure				p-value*
	Sim		Não		
	(n)	(%)	(n)	(%)	
Demographics					
Age Group	-	-	-	-	0.942
11 to 12 years	57	16.6	286	83.3	-
13 to 14 years old	79	17.3	377	82.6	-
15 to 17 years old	13	16.1	68	83.9	-
Sex	-	-	-	-	0.059
Female	67	14.6	391	85.3	-
Male	82	19.5	340	80.5	-
Health-Related Behaviors					
Regular consumption of greens and vegetables	-	0.529	-	-	-
No	82	83.3	380	16.7	-
Yes	67	16.1	351	83.9	-
Regular fruit consumption	-	-	-	-	0.926

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...continuação da tabela 2

Variables	High Blood Pressure				p-value*
	Yes		No		
	(n)	(%)	(n)	(%)	
No	93	17.7	450	82.3	-
Yes	56	16.6	281	83.4	
Regular consumption of junk food and sweets	-	-	-	-	0.070
No	85	19.2	356	80.8	-
Yes	64	14.5	375	84.5	-
Screen Time (PC/TV)	-	-	-	-	0.054
≥ 2 hours	33	22.4	114	77.5	-
< 2 hours	116	15.9	617	84.1	-
Health-Related Physical Fitness					
Cardiorespiratory Fitness	-	-	-	-	0.332
Risk Zone	138	16.7	692	83.3	-
Healthy zone	11	22.1	39	77.9	-
BMI	-	-	-	-	0.002
Overweight/Obesity	48	24.9	145	75.1	-
Thinness/Eutrophy	101	14.7	586	85.3	-
Visceral Fat	-	-	-	-	0.858
Risk Zone	9	15.5	49	84.5	-
Healthy zone	140	17.1	682	82.9	-
Overall Fat Percentage	-	-	-	-	0.104
Risk Zone	92	18.8	398	81.2	-
Healthy zone	57	14.6	333	85.4	-

(*) Pearson's chi-square test

Table 3 – Binary Logistic Regression to verify the factors associated with high blood pressure in adolescents from public schools (n=880). Montes Claros, MG, Brazil, 2017.

Variables	p-value	OR (95%CI)
Sex		
Male	0.043	1.45 (1.01-2.07)
Female	-	1.00
Screen Time (PC/TV)		
≥ 2 hours	0.426	1.17 (0.79-1.70)
< 2 hours	-	1.00
Regular consumption of sweets		
No	0.112	0.74 (0.51-1.07)
Yes	-	1.00
Overall Fat Percentage		
Risk Zone	0.594	1.10 (0.77-1.59)
Healthy zone	-	1.00
BMI		
Overweight/Obesity	0.001	1.96 (1.32-2.89)
Thinness/Eutrophy	-	1.00

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DISCUSSION

This study identified a high prevalence of high blood pressure among adolescents from public schools. The result is similar to what was observed in a study carried out in the Federal District[21] and in a city in the Southeast region of Brazil[22]. The literature reports very different values in epidemiological studies that assess BP among children and adolescents, which probably reflects more methodological and conceptual aspects. Most studies performed BP measurements once or twice, which can define high BP, but not SAH, according to the SBC guidelines. A study carried out in the city of Cuiabá (MT)[23] with adolescents, showed a prevalence of SAH of 4.27%, and a prevalence of HBP of 8.48%, while another study in the city of Fortaleza (CE)[24], with a group of children and adolescents between six and eighteen years old, found a prevalence of 44.7%.

The discrepancy in SAH values among adolescents has already been described by other authors in literature review analyses[12,25]. There was great variation between the different studies, which showed prevalences ranging from 2% to 30%. As limiting factors of the various studies, the authors highlighted the BP measurement method, the different equipment used, as well as the interpretation of blood pressure levels, which may have contributed to such a significant difference between the various references. In many studies, there is no description of the complete use of the Brazilian recommendation for BP measurement, which favors the overestimation of blood pressure levels.

International studies have shown that the prevalence of both HBP and SAH among children and adolescents is also variable[26,28]. The authors point out that hypertension in children is often underdiagnosed. The US Preventive Services Task Force highlights the importance of screening children and adolescents for SAH[26]. In Europe, there is also great variation in studies on the prevalence of SAH in the adolescent population, with rates ranging from 2.2 to 22%; this variation may be attributed to the continent's ethnic diversity and the different methodologies employed in the studies[27].

Regarding the associated factors, the present study identified that, for the assessed group, only high BMI and male gender were associated with the presence of high blood pressure. This result is pointed out in several studies and there seems to be a consensus in the literature regarding the role of overweight and obesity on the elevation of blood pressure levels[3-6,8-10,19,28-30].

The excessive accumulation of adipose tissue found in obese people triggers complex pathophysiological mechanisms that culminate in an increase in BP. Increased activity of the sympathetic nervous system in obese individuals is due to changes in baroreceptor control, with reduced parasympathetic tonus. In cardiac and renal muscle tissue, there is an increase in sympathetic activity, confirmed by the increase in renal norepinephrine[31].

The close relationship between high BMI and HBP is worrying, considering the growing increase in obesity among children and adolescents and the consequences of arterial hypertension. In 2017, a large study was published that analyzed the weight and height measurements of approximately 31.5 million children and adolescents, comparing obesity rates in this age group in the years 1975 to 2016. Obesity rates increased from less than 1% in 1975 to 6% in girls and 8% in boys in 2016. This worldwide study showed that, even in low- and middle-income countries, obesity demonstrates an increase in prevalence, which reflects upon the impact of marketing and food policies in the world, where healthier foods are more expensive for poorer communities. The conse-

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quence of this condition is the generation of a population of children and adolescents with high rates of overweight/obesity, which in the near future will develop associated complications, including arterial hypertension, in addition to diabetes mellitus, cardiovascular disease, and chronic kidney dysfunction[32].

The male gender has also been pointed out in the literature as a factor associated with high blood pressure, which are in line with the results of this study[3,19,30,33]. This finding is explained by hormonal issues, especially sexual steroids, which can influence blood pressure values starting in adolescence[34,35]. Among the possible explanations for the difference by sex, the authors of a meta-analysis discuss the role of intra-abdominal fat accumulation, which is greater in male adolescents. This accumulation would lead to greater sympathetic activity, which in turn would increase sodium reabsorption, causing an increase in peripheral vascular resistance and, consequently, in blood pressure[3].

Intra-abdominal fat leads to multiple pathogenetic mechanisms that contribute to the development of hypertension in obese individuals. There is an increase in pro-inflammatory cytokines, associated with hyperinsulinemia, increased activity of the sympathetic nervous system, activation of the renin-angiotensin-aldosterone system, in addition to an increase in abnormal levels of adipokines, such as leptin, which act on the vascular endothelium, causing metabolic and vasoactive disorders in adipose tissue and systemic vessels[3,36,37]. Increased plasma testosterone levels in this period of sexual maturation may also contribute to the difference. On the other hand, eating habits and healthy behaviors are influenced by several factors and these associations differ by sex[12].

In this study, eating habits are not associated with HBP. A study in Italy found direct associations between intake of "fast food" and SAH, while inverse associations were found between intake of vegetables, fruits, and nuts. The high prevalence of obesity and SAH and the significant correlations between some food categories and metabolic and vascular parameters suggest the importance of lifestyle modification policies at an early age to prevent the appearance of cardiovascular risk factors in childhood[28].

Also, no associations were identified between HBP and HRPF. The literature still shows a lack of consensus regarding the suggested benefits of physical activity on blood pressure patterns in the adolescent population[38]. So far, there are no standardized self-reporting instruments to measure physical activity, and there are some weaknesses related to the validation of these instruments. The use of different instruments may be responsible for the conflicting results in studies involving physical activity[8]. However, it is important to point out that, for the evaluated group, physical activity does not seem to be something done every day, considering the low percentage of young people classified in a healthy zone in terms of cardiorespiratory fitness. Thus, further studies are still needed to clarify this association. In line with the present study, the research by Sehn et al. did not find a significant association between screen time and LBP in children and adolescents[17].

It is important to consider some limitations of this study, among them the performance of a single BP measurement. The diagnosis of SAH requires at least three measurements in different environments. Although data from a single measurement does not configure a diagnosis, most studies use this measurement as an initial condition to advance in the diagnosis and follow-up of these students, seeking to intervene with modifiable factors related to SAH and, thus, achieve an improvement in blood pressure levels of these schoolchildren. Another limitation of this study is the use of students from public schools only. There are differences in the prevalence of obesity when comparing public and private school students. In a comparative study between students from public and private schools in

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the city of São Paulo, it was shown that these are significantly different groups[39].

Furthermore, the cross-sectional design prevents statements of cause and effect, and the use of a self-administered questionnaire allows memory bias and answers according to the interviewee's knowledge. Although cross-sectional studies do not allow for inferring causality, they are important to generate hypotheses and direct the planning of future studies, which may establish clearer relationships between factors related to SAH in adolescents.

Despite the limitations, the data found are relevant and warn that higher prevalence can be observed in private schools, where students have more access to a more diversified diet with greater caloric potential. It is important to consider that infectious diseases are no longer so prevalent in childhood and adolescence. Chronic non-communicable diseases have taken the primary place in this age group, bringing a great impact on quality of life, health expenses, and reduced life expectancy, justifying increasingly in-depth studies on their prevalence and pathophysiology. The importance of measuring BP in schoolchildren is directly related to the origin of SAH, which occurs in childhood. The longer the body is exposed to high blood pressure levels, the more chance there is of damage to target organs, loss of quality of life, spending on medication, as well as greater chances of early mortality.

CONCLUSION

There was a high prevalence of HBP among adolescents from public schools. Increased blood pressure was associated with male gender and being overweight. The school is the ideal environment to start screening children and adolescents with SAH, seeking to make them and their families aware of the importance of taking care of blood pressure and associated factors that can be removed. Thus, regular actions to promote a healthy lifestyle in schools are desirable as a way to prevent the premature development of chronic heart disease and cerebrovascular diseases.

Author Statement CREdiT

Conceptualization: Pinto, JHD; Pinho, L; Caldeira, AP. Methodology: Pinto, JHD; Fonseca, AA; Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Validation: Pinto, JHD; Caldeira, AP. Statistical analysis: Pinto, JHD; Fonseca, AA; Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Formal analysis: Pinto, JHD; Fonseca, AA; Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Investigation: Pinto, JHD; MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Resources: Pinto, JHD; Fonseca, AA; Caldeira, AP. Writing-original draft preparation: Pinto, JHD; Fonseca, AA; Caldeira, AP. Writing-review and editing: Pinto, JHD; Fonseca, AA; Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Visualization: Pinto, JHD; Fonseca, AA; Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Supervision: Brito, MFSF; Pinho, L; Rocha, JSB; Caldeira, AP. Project administration: Caldeira, AP.

All authors have read and agreed with the published version of the manuscript.

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