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Prevalence of high blood pressure among schoolchildren in Cuiabá, Midwestern Brazil

ABSTRACT

OBJECTIVE: The ways in which basal blood pressure levels are obtained may lead to different prevalence estimates. The objective of the study was to estimate the prevalence of high blood pressure among schoolchildren and to compare systolic and diastolic means obtained from three measurements of arterial pressure.

METHODS: This was a cross-sectional study among seven to ten-year-old schoolchildren (N=601) from public and private schools in the urban area of Cuiabá, midwestern Brazil, in 2005. Three different blood pressure measurements at ten-minute intervals were made during a single visit. Children were considered to have high blood pressure when their systolic and/or diastolic blood pressure reached levels greater than or equal to the 95th percentile in the reference table, in accordance with their gender, age and percentile height. To calculate the prevalence, the first and third blood pressure measurements were considered separately.

RESULTS: There were statistically significant differences between the systolic and diastolic means from the three measurements of the study. The mean systolic and diastolic pressures from the third measurement of the study were 97.2 mmHg (SD=8.68) and 63.1 mmHg (SD=6.66) respectively. The prevalence of high blood pressure was 8.7% (95% CI: 6.4;10.9) from the first measurement and 2.3% (95% CI: 1.1;3.5) from the third measurement. There was no statistical difference in prevalence in relation to age, sex, skin color and type of school.

CONCLUSIONS: In studies with a single visit, blood pressure measurements decrease significantly from the first to the third measurement. The third measurement seems to reveal blood pressure levels closer to the basal levels.

KEY WORDS: Child. Blood Pressure Determination. Hypertension, epidemiology. Epidemiologic Measurements. Cross-sectional studies.

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INTRODUCTION

Cardiovascular diseases are responsible for one third of all deaths in the world, and systemic arterial hypertension (SAH) is the most prevalent risk factor. SAH affects around 30% of the adult population worldwide, both in developed and in developing countries.[21]

Several longitudinal studies have suggested that SAH in adults is a disease that has its beginnings in childhood.[2,7,10,20] Because of the lack of routine examination and the belief that SAH is rare in childhood, many children have failed to receive the diagnosis of hypertension over recent decades.[18]

Sorof & Daniels[20] (2002) showed an inversion in the etiology of hypertension, with predominance of primary etiology among children, which is generally associated with obesity.

Adrogué & Sinaiko[1] (2001) reported SAH prevalence of 4.7% among American schoolchildren aged 10 to 15 years, while Maguire & Shelley[12] (1990) found a rate of 16% among Irish children aged 5 to 12. Data from some studies on SAH among Brazilian children indicate prevalences ranging from 3.6% to 16.6%.[4,13,16-18] These differences in prevalence rate are due, among other causes, to the different ways of obtaining basal blood pressure levels in these studies.

The present study had the objective of estimating the prevalence of high blood pressure levels among schoolchildren, and also to compare the systolic and diastolic pressure levels obtained from three measurements of arterial pressure.

METHODS

In 2005, a cross-sectional study was conducted among seven to ten-year-old elementary-level students of both sexes who were regularly enrolled in public and private schools in the urban area of Cuiabá, State of Mato Grosso, central-western region of Brazil.

According to data furnished by the State Department of Education of Mato Grosso (SEDUC-MT), 32,804 students within the age group of this study were enrolled in the 173 schools in the urban zone of the municipality (87.4%), in 2004. The estimated school attendance rate for the age group studied was 96% in 2004.

Because the prevalence of SAH among this population is unknown, it was considered for calculating the sample size, a prevalence of 50%, type I (alpha) error of 5% and sample error of five percents points. A two-stage sampling was adopted, using 20 clusters (schools).[3] A design effect of 1.5 was assumed.[11] To compensate for possible unit losses in the second stage, 20% of the calculated total was added to the sample. The 20 schools and 684 children who would take part in the study were then defined by a systematic selection. The parents' consent was requested by means of a letter.

The following children were considered to be sample losses: those for whom no consent was obtained after three attempts; those who, even though presenting the consent, refused to undergo the examinations; and those whose participation had been authorized but who were absent on the day of data collection.

A pilot study was carried out in one of the schools that was not selected, in which approximately 5% of the total number of children were examined. On that occasion, the equipment was calibrated, training was given, anthropometric methods were standardized, the conduct of the examinations was also standardized and audiometric assessments were performed by the principal investigator (LMPB).

The data collection was carried out during a single visit, by a fieldwork team formed by the principal investigator (the observer) and two assistants (one monitor and one logger), without wearing white coats.[6]

Data were collected to identify the children with regard to sex, age (7, 8, 9 or 10 years old), skin color (white, "pardo" or lightened black skin or black) and type of school attended (municipal, state or private). The circumference of the right arm at the midpoint between the olecranon and the acromion was noted and three measurements of systolic and diastolic arterial pressure were made, in mmHg.

Indirect arterial pressure measurements were made using a pediatric stethoscope with a diaphragm[5] (Glicomed), table-mounted mercury-column sphygmomanometer[5,14] (Glicomed), graduated every 2 mmHg, and Velcro armbands suitable for cuffs of 6 cm x 15 cm, 8 cm x 16 cm, 11.2 cm x 23.3 cm and 13.0 cm x 30.0 cm (Vitalmed). The minimum width for the cuff corresponded to 40% of the arm circumference, and the length to at least 80%, so that the minimum width-to-length ratio was 1:2.[14] The maximum arm circumference for which each cuff could be used was calculated.

The sphygmomanometer was set up in a room inside the school that was pleasant, well-ventilated, well-lit and as silent as possible.

It was checked that the child did not have a full stomach, had not taken medications or drunk coffee, and had not eaten and/or had physical exercise within the last 30 minutes before the measurements.[5] The measurements were made on the right arm placed on the line of the precordium, with the child in a seated position with his or her back supported and feet in contact with the floor or resting on a wooden step. The systolic arterial pressure was determined at the instant that the first sound appeared (K1) and the diastolic arterial pressure at the instant that the sound disappeared (K5).[8,14] The three blood pressure measurements[5] were made at ten-minute intervals.

To assess the quality of data collection, 10% of the sample was reevaluated by the same examiner. The instruments were periodically calibrated at the Metrology and Quality Institute of Mato Grosso (IMEQ-MT). Terminal digit analysis[5] and reliability measurements were frequently performed, using intraclass correlation coefficients.

To categorize the blood pressure levels, the tables from the Fourth Report of the American National High Blood

Pressure Education Program[14] (NHBPEP) were used, taking into consideration the children's sex, age and height percentile. Children with systolic and diastolic pressures less than the values corresponding to the 90th percentile were considered to be normal. Children whose systolic and/or diastolic pressure levels were greater than or equal to the 90th percentile and less than the 95th percentile were considered to be pre-hypertensive. Children whose systolic and/or diastolic pressure levels were greater than or equal to the 95th percentile were considered to present high blood pressure or to be supposedly hypertensive.

The height percentile curves according to age and sex followed the proposals from the Centers for Disease Control and Prevention (CDC).[9]

For the purposes of calculating prevalences, the pressure levels from the first and third blood pressure measurements were considered separately.

The Chi-square test, or Fisher exact test when necessary, was used to test differences between proportions. Analysis of variance (ANOVA) was used for comparisons between means. The paired Student's t-test was used for comparisons between means coming from the same individuals at different times. The analyses were performed using the SPSS 10.0.1 software. All the analyses took into consideration the study sample design.

The study had been approved by the Research Ethics Committee of the Universidade Federal de Mato Grosso, and the Departments of Education and Health of the State of Mato Grosso and the municipality were made aware that the study was being conducted. The parents were all informed about their children's blood pressure levels. Children who were considered to be hypertensive were referred for outpatient follow-up with the aim of confirming the diagnosis.

RESULTS

The ranges for the reproducibility of the three systolic and diastolic measurements were, respectively, 0.65-0.75 and 0.53-0.62. The chi-squared test carried out to check the terminal digits found values ranging from

Table 1. Distribution of the schoolchildren studied, according to sociodemographic characteristics, type of school, examination time and cuff dimensions. Cuiabá, Midwestern Brazil, 2005. N=601

Characteristic	N	%
Age (years)		
7	157	26.1
8	161	26.8
9	138	23
10	145	24.1
Sex		
Male	293	48.8
Female	308	51.2
Skin color		
White	124	20.6
Non-white	477	79.3
Type of school		
Public	578	96.2
Private	23	3.8
Examination time		
Morning	242	40.3
Afternoon	359	59.7
Cuff (cm x cm)		
6 x 15	10	1.7
8 x 16	443	73.7
11.2 x 23.3	145	24.1
13 x 30	3	0.5

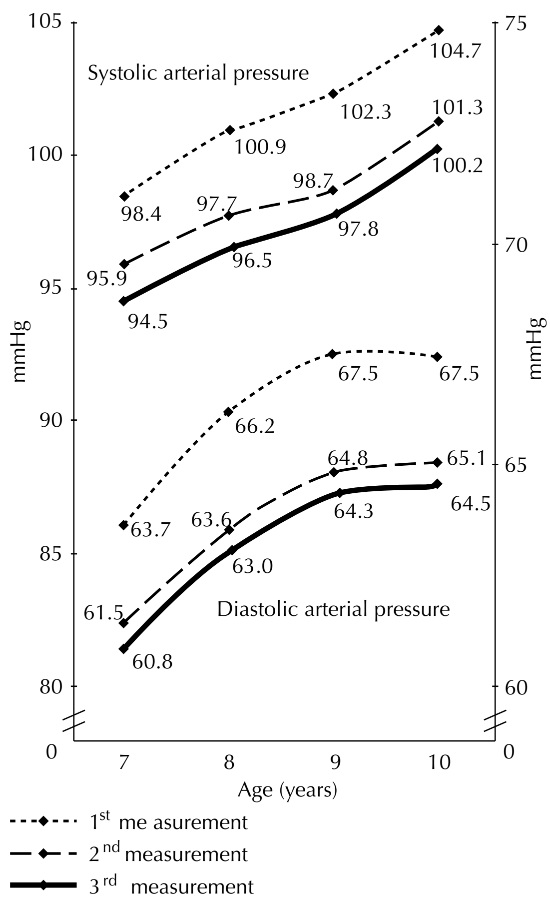

Figure. Mean systolic and diastolic arterial pressure according to age, for the first, second and third blood pressure measurements made among schoolchildren. Cuiabá, Midwestern Brazil, 2005. (n=601)

2.5 to 6.4 and did not exceed the critical value (9.49) for the degree of freedom of the test with type I error of 5%. The design effect obtained was 1.8. Among the 684 children selected for performing the examinations, 601 (87.9%) were evaluated. The ages were similar between the losses and the children studied.

The mean age among the schoolchildren studied was 8.45 years (SD=1.12). There were 308 girls (51.2%) and 578 students (96.2%) attended public schools (Table 1).

The means and standard deviations of the three systolic and diastolic measurements made for the study can be seen in Table 2. There were significant differences in the systolic and diastolic means between the first and second measurements, between the first and third measurements and between the second and third measurements. The mean systolic and diastolic arterial pressure levels in the three measurements increased with increasing age (Figure 1).

Decreases of 3.2 mmHg (3.2%) between the systolic means and 2.4 mmHg (3.6%) between the diastolic means from the first and second measurements were observed. Between the first and third measurements, the decreases were 4.3 mmHg (4.2%) between the systolic means and 3.0 mmHg (4.8%) between the diastolic means.

Considering the third measurement, the systolic and diastolic means were seen to be similar between the sexes (p=0.91 and p=0.57), skin colors (p=0.89 and p=0.84), types of school attended (p=0.77 and p=0.81) and examination times (p=0.73 and p=0.21).

Table 2. Means and standard deviations (SD) of the schoolchildren's systolic and diastolic arterial pressure, in the three measurements made in the study, according to age. Cuiabá, Midwestern Brazil, 2005.

Arterial pressure measurements (mmHg)	Age (years)*								p**	Total	
	7		8		9		10				
N	157		161		138		145			601	
1st systolic measurement	98.4	(9.3)	100.9	(9.6)	102.3	(8.8)	104.7	(9.7)	< 0.001	101.5	(9.6)
1st diastolic measurement	63.7	(7.7)	66.2	(7.6)	67.5	(7.6)	67.5	(7.7)	< 0.001	66.1	(7.8)
2nd systolic measurement	95.9	(8.6)	97.7	(9.4)	98.7	(8.3)	101.3	(9.0)	< 0.001	98.3	(9.0)
p***	< 0.001		< 0.001		< 0.001		< 0.001			< 0.001	
2nd diastolic measurement	61.5	(7.0)	63.6	(6.5)	64.8	(7.2)	65.1	(6.9)	< 0.001	63.7	(7.0)
p***	< 0.001		< 0.001		< 0.001		< 0.001			< 0.001	
3rd systolic measurement	94.5	(8.2)	96.5	(9.0)	97.8	(7.8)	100.2	(8.7)	< 0.001	97.2	(8.7)
p ****	< 0.001		< 0.001		< 0.001		< 0.001			< 0.001	
p *****	< 0.001		< 0.001		0.001		< 0.001			< 0.001	
3rd diastolic measurement	60.8	(6.7)	63.0	(6.2)	64.3	(6.9)	64.5	(6.3)	< 0.001	63.1	(6.7)
p ****	< 0.001		< 0.001		< 0.001		< 0.001			< 0.001	
p *****	0.014		0.04		0.06		0.061			< 0.001	

* 7 years (7.0-7.9 years); 8 years (8.0-8.9 years); 9 years (9.0-9.9 years) and 10 years (10.0-10.9 years)
** ANOVA between the ages
*** Paired Student's t test between first and second measurements (systolic and diastolic)
**** Paired Student's t test between first and third measurements (systolic and diastolic)
***** Paired Student's t test between second and third measurements (systolic and diastolic)

Table 3 shows that the prevalence of high blood pressure levels was 8.7% in the first measurement and 2.3% in the third measurement, and this difference was statistically significant (p<0.001). There was no statistical difference between the prevalences of "hypertensive" children (p=0.37) and "pre-hypertensive" children (p=0.27) in the second and third measurements of the study.

The prevalences of schoolchildren considered to be hypertensive and pre-hypertensive, taking the blood pressure levels found in the third measurement, were not seen to be different between the ages, sexes, types of school and times when the examination was done (Table 4). The mean age among the normotensive children was 8.45 years (SD=1.12) and among the hypertensive children it was 8.64 years (SD=1.01).

Table 3. Prevalence of high blood pressure levels among the schoolchildren, in three measurements. Cuiabá, Midwestern Brazil, 2005. N=601

Obtaining of basal arterial pressure	Hypertension (99 ≥ Percentile ≥ 95)			p	Pre-hypertension (95 > Percentile ≥ 90)			p	Normal tension (Percentile < 90)		
	N	%	95% CI		N	%	95% CI		N	%	95% CI
1st measurement	52	8.7	6.4;10.9		77	12.8	10.1;15.5		472	78.5	75.3;81.8
2nd measurement	19	3.2	1.8;4.6	< 0.001*	31	5.2	3.4;6.9	< 0.001*	551	91.6	89.5;93.9
3rd measurement	14	2.3	1.1;3.5	< 0.001** 0.37***	23	3.8	2.3;5.4	< 0.001** 0.27***	564	93.9	91.9;95.8
p****	< 0.001				< 0.001				< 0.001		

* Chi-square test between 1st and 2nd measurements
** Chi-square test between 1st and 3rd measurements
*** Chi-square test between 2nd and 3rd measurements
**** Chi-square test for linear trend

Table 4. Distribution of prevalence of high blood pressure levels using the third measurement, according to the schoolchildren's characteristics. Cuiabá, Midwestern Brazil, 2005.

Variable	Prevalence: Hypertensive individuals (Percentile ≥ 95)			p*	Pre-hypertensive individuals (95 > Percentile ≥ 90)			p*
	N	%	95% CI		N	%	95% CI	
Age (years)				0.61				0.88
7	2	1.3	0.0;3.0		6	3.8	0.8;6.8	
8	4	2.5	0.1;4.9		7	4.3	1.2;7.5	
9	5	3.6	0.5;6.7		6	4.3	0.9;7.7	
10	3	2.1	0.0;4.4		4	2.8	0.1;5.4	
Sex				0.47				0.90
Male	5	1.7	0.2;3.2		11	3.8	1.6;5.9	
Female	9	2.9	1.0;4.8		12	3.9	1.7;6.1	
Skin color				1.00**				0.80**
White	3	2.4	0.0;5.1		5	4	0.6;7.5	
Non-white	11	2.3	1.0;3.7		18	3.8	2.1;5.5	
Type of school				0.42**				1.00**
Public	13	2.2	1.0;3.5		23	4	2.4;5.6	
Private	1	4.3	0.0;12.7		–	–	–	
Examination time				0.94				0.74
Morning	5	2.1	0.3;3.6		8	3.3	1.1;5.6	
Afternoon	9	2.5	0.9;4.1		15	4.2	2.1;6.2	

* Chi-square test
** Fisher's exact test
(–) Null value

To classify the schoolchildren's blood pressure levels, the pressure levels obtained from the third measurement were used and the NHBPEP categorization criteria were followed.[14] Thus, the prevalences found were: stage 2 hypertension in 0.3% of the children; stage 1 hypertension in 2.0%; pre-hypertension in 3.8%; and normal tension in 93.9%.

DISCUSSION

The wide variation in the prevalence of hypertension in national and international epidemiological studies is basically due to methodological factors. As recognized by Oliveira et al[17] (1999) and by Salgado & Carvalhaes[19] (2003), factors such as the age group studied, number of visits made, number of measurements at each visit and interval between measurements contribute significantly towards this variation.

According to the Fourth Report published by NHBPEP[14], a diagnosis of hypertension in children is only made after verifying that the mean systolic and/or diastolic pressure on more than three distinct occasions is greater than or equal to the pressure level corresponding to the 95th percentile (taking into account sex, age and height percentile) of a reference population. In recognition of this criterion and accepting the limitations of the present study, it was decided to use the expression "prevalence of high blood pressure", instead of the expression "prevalence of hypertension" that is routinely used in epidemiological studies.

Assessment of the quality of the data collected is an important part of determining the quality and construction of the results. Analysis of the terminal digits has been shown to be an important procedure in epidemiological studies on arterial pressure that use mercury-column sphygmomanometers. This is because it is not unusual for examiners to prefer some digits to the detriment of others during the procedure of reading from the apparatus. This was seen during the pilot study. Because of this, it is considered to be important to check whether the differences between the percentages of terminal digits observed and expected are due to chance or the examiners' inherent bias.

The intraclass correlation coefficient obtained was deemed to show good intra-observer concordance and lack of bias in preferences for terminal digits when reading the pressure levels. Thus, the quality of data collection was considered to be very satisfactory. Nonetheless, some methodological weakness must be taken into consideration.

Gillman & Cook[5] (1995) recommended that, for epidemiological studies, at least three arterial pressure measurements should be made, at a minimum of two distinct visits, because they found a significant decrease in pressure levels at subsequent visits. In the present study, the decision to make a single visit for determining the children's basal arterial pressure partially goes against this recommendation. As a consequence of this decision, which was made for practical reasons, there might theoretically have been an overestimation of the prevalence rates for high blood pressure.

No guidance was found in the literature regarding the ideal time interval between arterial pressure measurements for conducting non-outpatient epidemiological studies. In the present study, it was decided to make arterial pressure measurements at ten-minute intervals, as also done by Oliveira et al[17] in 1999. It is believed that this decision may have minimized the above-mentioned hypothetical overestimation, considering that other studies conducted in Brazil obtained higher prevalences by using two-minute intervals between the measurements.[13,18]

The variations in systolic and diastolic pressure levels that occur over the course of the day may have had an influence on the prevalence of high blood pressure levels.[5,15] However, as reported by Gillman & Cook[5] (1995), spontaneous rises in arterial pressure occurred in both the morning and the afternoon. This could be seen in the present study through the absence of any significant difference between the prevalences at the times when the children were examined.

The use of a suitable cuff, both in clinical practice and in epidemiological studies, is an important point in diagnosing abnormal blood pressure levels in childhood.[8] Incorrect choice in relation to arm circumference may cause underestimation or overestimation of the systolic and diastolic arterial pressure levels.[5] In the present study, there were in effect four cuff sizes, which demonstrates the variability of arm circumference among children. In accordance with the NHBPEP recommendations, careful use of different cuff sizes in epidemiological studies is emphasized.[14]

Because of the lack of standardization among the research protocols of Brazilian studies on hypertension in childhood, it was decided to use the NHBPEP reference tables.[14] Thus, the fact that these reference tables come from studies that made a single blood pressure measurement was accepted.[7,14] The first measurements made in the present study were those chosen for comparison with the NHBPEP database. Thus, the schoolchildren in Cuiabá presented a prevalence of high blood pressure levels of 8.7%. This was a rate similar to what was found in Brazilian studies that considered the first arterial pressure measurement to be most representative of the basal pressure levels.[4,17]

In the present study the prevalences of "hypertensive" and "pre-hypertensive" children found from the second measurement did not differ from the rates found from the third measurement. This puts into question the pertinence of making the third measurement in epidemiological studies since, from a practical point of view, the study would be simplified if only two measurements were made. However, from analysis of the mean systolic and diastolic pressure levels in the second and third measurements, it was seen that the decrease in systolic and diastolic pressure levels from one measurement to the other was statistically significant. This pattern of decreasing blood pressure levels in consecutive measurements was also observed by Oliveira et al[17] (1999) and could be partially explained by decreased anxiety when another examination was made, among a large percentage of the children.

The third measurement produced blood pressure levels that were closer to what would be considered basal levels, and hence more trustworthy prevalence rates. The prevalence of high blood pressure levels estimated from the third measurement was 2.3%, and this was not different from the rate of 3.5% that was found in the second measurement, but it was significantly lower than the prevalence found in the first measurement.

The prevalence in this third measurement did not differ statistically from the prevalence rates found by Oliveira et al (2004)[16] in Feira de Santana (State of Bahia) (3.6%), Oliveira et al (1999)[17] in Belo Horizonte (State of Minas Gerais) (3.9%) and Rezende et al (2003)[18] in Barbacena (Minas Gerais) (2.5%). However, it differed from the rates found by Brandão (1987)[4] in Rio de Janeiro (State of Rio de Janeiro) (6.9%) and Moura et al (2004)[13] in Maceió (State of Alagoas) (6.5%).

No statistical significance found between the prevalences of hypertension and pre-hypertension in any of the categorical variables studied is explained by the lack of statistical power of the present study, in comparison with the low prevalences coming from the subpopulations of each of the categories.

The diversity of methodologies that have been used makes it difficult to compare results and contributes enormously towards the discrepant prevalences between the different Brazilian studies. Among the methodological variations, the following can be cited: type of sphygmomanometer, positioning of the child, cuff selection criteria, number of measurements made, interval between the measurements and criteria for defining the basal blood pressure levels to be used in defining which individuals were considered hypertensive, and also all the details inherent to the quality of the data collection.

The statistically significant difference in blood pressure levels between the first and the other measurements made in the present study, makes it inadvisable to use single measurements for obtaining basal blood pressure levels in epidemiological studies. On the contrary, performing a first and a second arterial pressure measurement was shown to be important since, within the general context of conducting epidemiological studies, this puts the child in contact with all the measurement procedures. This approach contributes substantially towards decreasing the blood pressure levels in subsequent measurements.

The results indicate that the third measurement seems to be more representative of the basal blood pressure levels among schoolchildren in epidemiological studies. Moreover, regardless of the three arterial pressure measurements is taken into consideration, high blood pressure levels are present among a reasonable proportion of schoolchildren.

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