Original Article

Blood pressure and its associated factors among primary school children in suburban Selangor, Malaysia: A cross-sectional survey

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ABSTRACT

Background: Little is known about the relationship of blood pressure (BP) with adiposity indicators, dietary habits, physical activity, and sleep in school children in Malaysia. We aimed to study about the distribution of BP and its associated factors in primary school children. **Materials and Methods:** A survey was carried out on a random sample of 335 children in five primary schools. BP was measured with a mercury sphygmomanometer. Anthropometry was done by standard methods. Demographic information, dietary habits, physical activity, and duration of sleep were collected by interviews. World Health Organization classification based on body mass index (BMI) and waist circumference (WC) cut-offs were used to define overweight/obesity. Elevated BP was defined according to US reference standards. **Results:** A total 335 children (144 boys and 191 girls) were examined. Their mean age was 9.18 years (standard deviation [SD] = 0.28). Overall mean systolic blood pressure (SBP) and mean diastolic blood pressure (DBP) were 99.32 mmHg (SD = 10.79) and 67.11 mmHg (SD = 10.76), respectively. Mean BMI and WC were 16.39 (SD = 3.58) and 57.77 cm (SD = 8.98), respectively. The prevalence of pre-hypertension was 12.23% (95% confidence intervals [CIs] 8.73, 15.75) and hypertension was 13.4% (95% CIs 9.78, 17.09). Mean SBP and DBP was higher among overweight and obese children than normal children. By multivariate linear regression analyses, BMI (β = 0.250, P = 0.049) and WC (β = 0.308, P = 0.015) were positively associated with SBP; age (β = 0.111, P = 0.017), BMI (β = 0.320, P = 0.012) were positively associated with DBP but total (weekly) hours of sleep (β = −0.095, P = 0.037) was negatively associated with DBP. **Conclusion:** BP was associated with BMI and WC. Health promotion activities should be initiated in primary schools.

Key words: Blood pressure, body mass index, cross-sectional survey, obesity, school children, waist circumference

INTRODUCTION

An estimated 20 million people may die from cardiovascular diseases (CVDs) such as heart disease and stroke by 2015.[1] The burden of these diseases is on the rise in most developing nations including Malaysia.[2] In adults, hypertension is a leading cause of morbidity worldwide. Hypertension is a major risk factor for CVDs and has its roots in childhood.[3-5] Pediatric hypertension is also known to cause long-term cardiovascular morbidity and interferes with cognitive function.[6-10] Childhood overweight and obesity are known to increase the risk of cardiovascular morbidity, irrespective of whether obesity persists into adulthood.[11-14] Studies from India, China, and Indonesia have reported the prevalence of childhood hypertension.[15-22] A study from Sabah, Malaysia has reported that the prevalence of hypertension among children aged 8-9 years old was 14%.[23]

Epidemiological studies have linked childhood hypertension to various adiposity indicators.[8,18-20,24-33]

Some studies have shown that obesity defined as body mass index (BMI) of ≥95 percentile based on gender and age does not correlate well with body fat distribution as compared with waist circumference (WC) which is more accurate in predicting abdominal mass, thus correlating better with hypertension in children.[24,34] However, studies have consistently reported that elevated blood pressure (BP), systolic blood pressure (SBP), and diastolic blood pressure (DBP) are significantly correlated with BMI.[15-18-20,29,31-33] Some studies have investigated the association of childhood hypertension with skin fold thickness, hip circumference, birth weight, dietary habits, and family history of hypertension.[15,18,20,32-34] The relationship of childhood hypertension with the total number of hours of sleep, physical activity, and dietary intake are seldom reported.[15,35-37]

Obesity in adults is a public health problem in Malaysia.[38] The prevalence ranges from 9% to 23% in urban areas.[39-42] However, no study has been published on childhood hypertension in the Malaysian peninsula. A study from Sabah, Malaysia has reported that 50% of obese children also had hypertension.[23] However, this study did not report the association of BMI, WC with childhood hypertension or collect data on dietary intake and physical activity. We aimed to study the distribution of BP and its relationship with BMI, WC, dietary habits, physical activity, and duration of sleep in primary school children.

MATERIALS AND METHODS

Study design, setting, and participants
A cross-sectional school survey was conducted among primary school children in a sub-urban area of Selangor state in Malaysia during August and September, 2012. Selangor state has different types of primary schools, namely, National schools, Chinese schools, and Tamil schools. The participants were primary school children. In each selected school, children in class three who were present on the day of survey were selected. Children who were Malaysian citizens and whose parents had given written consent were eligible to participate.

Sample size calculation and sampling method
An epidemiological study carried out in 2008-2009 reported the prevalence of 17.9% for overweight and 16.0% for obesity in primary school children of Kuala Lumpur and Selangor.[39] We assumed that the prevalence of obesity would be 20%. Other assumptions made were for 95% confidence level and 20% allowable error. The sample size was calculated using the formula: $N = Z^2 p (1 - p)/d^2$, where N is the sample size, $Z_{0.05}$ is 1.96 (for 95% confidence level), p is the anticipated prevalence of the parameter (20%) and

d is the allowable error (as % of p). The required sample size calculated was 384 children.

From the list of schools in Selangor, we selected two National and three Chinese primary schools by simple random sampling (lottery method). Proportional allocation of schools or classes was not possible since the number of children enrolled in each school or class was not available. Then from each school, we randomly selected three classes belonging to year 3. Tamil schools were not selected because we anticipated that both National and Chinese primary schools would have some children of Indian origin (mainly Tamil speaking).

Ethical considerations
Ethical clearance for the survey was obtained from the Scientific and Ethical Review Committee of University Tunku Abdul Rahman. A written permission was obtained from the Ministry of Education. A verbal consent from the head master/mistress of each selected school and a written parental consent was obtained before conducting the health examination.

Study variables and their definitions
Dependent variables were SBP and DBP. Independent variables were socio-demographic information about the child, WC, height, weight, dietary habits, physical activity, and total sleep duration. The socio-demographic data provided in a parental consent form were the date of birth, ethnicity, parents' education, and income. Pre-tested questionnaires in two languages (i.e., Mandarin and English for Chinese schools, Bahasa Melayu and English for National schools) were used. A food frequency questionnaire containing 41 items was adapted from a previous study done in Selangor, Malaysia.[43] The questionnaire assessed the meal pattern for breakfast, lunch, dinner, and snacks; the frequency of eating different types of food in a week in the past 6 months. The frequency of the intake of different types of foods was recorded as: (1) Daily, (2) 1-3 times/week, (3) 4-6 times/week, and (4) never/rarely. To assess the level of physical activity during the previous 7 days, child physical activity questionnaire (C-PAQ) was used.[44] The participants were asked about their spare time activities, activities during physical education classes, recess, after school hours and also at the weekends. The responses for frequency of undertaking different physical activities in a week were recorded as: (1) Never, (2) 1-2 times, (3) 3-4 times, (4) 5-6 times, and (5) >6 times. For the purpose of our data analyses, 41 food items were grouped into six food categories, that is, (1) cereals, (2) non-vegetarian foods, (3) vegetables and fruits, (4) oils and fats, (5) dairy products, and (6) sweetened drinks. Total food frequency score for each of the six categories of foods was then calculated by summing up the responses for each food types. Responses

obtained from C-PAQ were converted into a composite score by calculating the mean score of all five items in C-PAQ.

BP and anthropometric measurements were done according to international guidelines. All the instruments were checked for calibration before the survey. Body weight was measured in light clothing, without shoes and heavy materials such as wallet or hand phones, to the nearest 0.1 kg using a SECA digital weighing machine (model 769) (SECA Medical Scales and Measuring Systems, Birmingham, United Kingdom). Height was measured to the nearest 0.1 cm using a height measurement rod (model 220) attached to the SECA digital weighing machine. Waist circumference (WC) was measured with a non-elastic flexible tape (SECA 200) at the end of expiration, at the level of the midpoint between lower costal border and iliac crest. For all anthropometric measurements two readings were taken and the average of two readings was adopted. BMI was calculated using the formula (kg/m^2). Children were categorized into different weight groups using World Health Organization (WHO) BMI-for-age (2007) reference charts for children aged 5-19 years.[45] They were also classified as obese and non-obese based on WC cut-off at ≥90th percentile for Malaysian children as recommended by Poh *et al*.[46]

BP was measured by the auscultatory method using a mercury sphygmomanometer (Accoson, UK), pediatric cuff (pediatric cuff sizes: 6" × 3" or 150 mm × 75 mm and 7.5" × 4" or 187 mm × 10 mm) and a stethoscope. Before each school visit, a medical doctor calibrated the sphygmomanometer. For BP measurement, each child was initially asked to rest for a period of at least 5 min, with their right arm positioned on a table situated at the level of child's heart. After first reading the child was told to remain seated quietly for at least for another 5 min before a second measurement was taken. SBP was determined by Korotkoff phase-I sound (i.e., snapping sound heard at first) and DBP was determined by Korotkoff phase-V sound (i.e., disappearance of sound). An average of two readings for SBP and DBP were used for analyses and was classified as normal BP, pre-hypertension, grade-1 and grade-2 hypertension using EZ BP calculator (http://www.ezbmi.com/BP_Calculator.htm). This online calculator is based on the recommendation by the National High Blood Pressure Education Program (NHBPEP) working group on hypertension control in children and adolescents.[47] NHBPEP defines high BP in children as SBP and/or DBP values at ≥90th percentile, considering sex, age, and height as follows:

A. Normal BP: <90th percentile.
B. Prehypertension: BP between the 90th and 95th percentile or >120/80 mmHg in adolescents.

C. Hypertension: BP >95th percentile on repeated measurement
    I.   Stage 1: The 95th percentile to the 99th percentile plus 5 mmHg.
    II. Stage 2: >99th percentile plus 5 mmHg.

Survey data collection
Data collection was done by 2nd year undergraduate medical students who were given hands-on training. The training sessions covered an interview technique, anthropometry, and BP measurement. After the training, a pilot study was done with 10 volunteers to calculate inter-rater agreement for these measurements. All the observers were blinded. Inter-observer correlation coefficient was >0.95 for all anthropometric measurements, but for BP measurement inter-observer correlation coefficients were 0.66 and 0.58 for SBP and DBP, respectively. During the survey, the same group of students performed the given tasks for all children. For example, students were grouped into separate teams for different activities such as measurements of height, weight, WC, BP, and interviews. All measurements and interviews were overseen by their academic supervisors for quality control.

Data analysis
Data analysis was performed using the Statistical Package for Social Sciences (SPSS Inc. Chicago, USA) package version 19.00. Prevalence rates and their 95% confidence intervals (95% CIs) for BP categories were calculated. Elevated BP was compared to BMI categories and abdominal obesity (WC criterion). Mean SBP and mean DBP were also compared between BMI categories (WHO classification) and abdominal obesity (WC criteria). SBP, DBP, BMI, and WC were compared to demographic variables. Independent samples "*t*"-test and one way analysis of variance (ANOVA) were used as appropriate. Bivariate correlation coefficients were calculated for SBP and DBP, against BMI, WC, food frequency scores, physical activity score, and total hours of sleep in a week. The association of SBP and DBP with explanatory variables was assessed using the multiple linear regression analysis by enter method. Explanatory variables, which had a $P < 0.05$ in bivariate correlations were entered into multiple linear regression analyses. The beta-coefficients, P values and their 95% CI were calculated.

RESULTS

Of the 335 children who were examined, 144 (43%) were boys and 191 (57%) were girls. Their mean age was 9.18 years (standard deviation [SD] = 0.28). Ethnic distribution as Malays, Chinese and Indian and others was 47.5%, 46%, and 6.3%, respectively. Overall mean SBP and DBP were 99.32 (SD = 10.79) and 67.11 (SD = 10.76),

respectively, and mean BMI and WC were 16.39 (SD = 3.58) and 57.77 (SD = 8.98), respectively. All comparisons of SBP, DBP, BMI, and WC according to sex, ethnicity, and monthly family income were not statistically significant except for gender. Mean WC for girls was significantly lower than that for boys [Table 1]. Prevalence of pre-hypertension was 12.23% and hypertension (grade-1 and grade-2) was 13.4%. By WHO classification, prevalence of thinness, overweight, and obesity were 14.4%, 11.3%, and 12.2%, respectively. Prevalence of obesity on the basis of WC (>95th percentile) was 13.7% [Table 2].

The prevalence of elevated BP was 41.8% in children who were overweight and/or obese and 18.3% in children who were normal based on WHO BMI classification. The Mean SBP in overweight and/or obese children was 11.05 mmHg higher than normal children, whereas the mean DBP in overweight and/or obese children was 10.44 mmHg higher than normal children [Table 3]. The prevalence of elevated BP was nearly 9 times higher in children who had abdominal obesity than non-obese children (37.4% vs. 4.2%) (based on WC criteria). The mean SBP in obese children was 15.8 mmHg higher than non-obese children, whereas the mean DBP in obese children was 14.49 mmHg higher than in non-obese children [Table 3].

On bivariate linear correlation analysis, SBP was significantly positively associated with BMI ($r = 0.540$), WC ($r = 0.545$), C-PAQ score ($r = 0.126$), non-vegetarian foods ($r = 0.124$), and negatively associated with food frequency scores for cereal based foods ($r = -0.108$). Similarly, DBP was positively associated with age ($r = 0.173$), BMI ($r = 0.544$), WC ($r = 0.538$) and negatively associated with total (weekly) hours of sleep ($r = -0.108$) [Table 4]. Multiple linear regression analysis showed that BMI ($\beta = 0.250$, $P = 0.049$) and WC ($\beta = 0.308$, $P = 0.015$) were positively associated

with SBP; age ($\beta = 0.111$, $P = 0.017$), BMI ($\beta = 0.320$, $P = 0.012$) were positively associated while total (weekly) hours of sleep ($\beta = -0.095$, $P = 0.037$) was negatively associated with DBP after adjustment with other explanatory variables [Table 5].

DISCUSSION

To the best of our knowledge, this is the first study on prevalence of BP in school children in the Malaysian peninsula. We found a high prevalence of overweight and obesity but a lower prevalence of thinness in the school children. The prevalence of hypertension was also high in children aged 9-10 years. More than a third of the children who were over-weight or obese by (BMI criterion) or had abdominal obesity (WC criterion) had elevated BP. Both SBP and DBP had a linear relationship with BMI and WC. Identifying relationship of BP with BMI and WC in school children in Malaysia is important since persistently elevated BP in children may lead to irreversible cardiovascular sequelae, and both obesity and elevated BP during childhood may persist into adulthood.[4,7-9]

Our results should be interpreted with caution considering the following limitations. Prevalence of elevated BP may be an over-estimate since research has shown that on repeated measurements of BP, the prevalence of high BP would decrease by nearly half.[48] The information about dietary habits and physical activity by interviews may have been affected by recall bias. Our sample may not have had sufficient statistical power to detect the relationship of SBP and DBP with variables such as dietary habits, physical activity, and total hours of sleep. The US reference data used for defining elevated BP, has an advantage of being adjusted for physiological factors (i.e., sex, age, and height)

Table 1: Distribution of participants and their BP, BMI and WC according to demographic variables

Variable	Number (%)	SBP (mean and SD)	DBP (mean and SD)	BMI (mean and SD)	WC (mean and SD)
Overall	335	99.32 (10.79)	67.11 (10.76)	16.39 (3.58)	57.77 (8.98)
Gender					
Boys	144 (43)	99.49 (11.08)	67.16 (10.42)	16.63 (3.53)	59.27 (9.42)†
Girls	191 (57)	99.19 (10.59)	67.08 (11.04)	16.20 (3.61)	56.63 (8.49)
Ethnicity					
Malay	159 (47.5)	98.05 (10.89)	67.11 (10.59)	16.28 (3.81)	56.98 (8.86)
Chinese	154 (46)	100.56 (10.55)	66.65 (10.61)	16.37 (3.21)	58.20 (8.82)
Indian and others	22 (6.3)	99.77 (11.01)	70.41 (12.90)	17.25 (4.33)	60.39 (10.64)
Monthly family income (in Malaysian Ringgits)*					
<2000	82 (24.5)	97.77 (11.62)	66.78 (10.96)	16.13 (3.42)	57.57 (9.27)
2001-5000	136 (40.6)	100.31 (10.69)	67.18 (10.85)	16.46 (3.63)	57.80 (9.07)
≥5001	98 (29.3)	99.30 (10.66)	67.53 (11.03)	16.57 (3.80)	58.0 (9.08)

†*P*=0.008; BP: Blood pressure; BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure, *Data was not available for 19 participants; SD: Standard deviation; BP: Blood pressure

known to cause BP variations in children.[47] However, the application of such reference BP values to Asian children is debatable.[25]

The prevalence rates of overweight and obesity were similar to studies reported from the states of Kuala Lumpur, Selangor, and Kelantan, in Malaysia.[39-42] However, of these studies, only one reported under-weight/thinness according to the WHO recommended z-scores. Contrary to previous studies, there were no significant differences in SBP, DBP, and BMI according to sex, ethnicity, and income of the parents.[21,25,29,31,32] Girls had a significantly lower WC than boys which is probably a biological phenomenon. The relatively small sample in our study may be a reason for not finding significant differences by ethnicity, gender, and income. The prevalence of elevated BP and mean BP are not comparable with studies reported from other countries for several reasons.[26] First, age group of children examined varied across the studies. Second, the criterion for defining elevated BP in published studies was not uniform. Third, the instrument

used in measuring BP (automated oscillometric monitors, as opposed to auscultatory mercury sphygmomanometers) could have provided varying results. Fourth, we did not use the persistence of elevated BP measured on two or more days, which is an accepted criterion for high BP adopted by some epidemiological studies.[15,19,29,31] Furthermore, normal BP range is known to vary according to the size of the cuff, type of sphygmomanometer, position of the arm, whether fourth or fifth Korotkoff sounds was considered for DBP, time of the day and conditions in which BP was measured. BP is also known to vary according to sex due to biological and psychosocial factors. Lastly, studies about BP in school children lacked standardized methods for the measurement of BP.

Findings of linear relationship of BMI and WC with SBP and DBP in our survey are consistent with studies from other developing[15,16,19,20,25,28,29] and developed countries.[24,31,33,34,48,49] A study from Mexico reported that both SBP and DBP were higher in obese children, and that there was a linear relationship between BP and BMI;[31] similar results were reported from Seychelles, Africa.[25] A study from Taiwan showed that WC had a linear relationship with SBP and DBP,[34] whereas a study from Italy reported that both BMI and WC were strong determinants of BP.[24] Although different anthropometric measurements were found to have an association with elevated BP or with SBP and DBP, we treated SBP and DBP as continuous variables to avoid a bias of misclassification. However, after classification, the prevalence of high BP was very high among children who had abdominal obesity (according to WC criterion). The prevalence of elevated BP in overweight or obese children was 2 times higher than normal children (based on BMI criterion). Despite these consistent associations, a review of epidemiological studies has concluded that there is very little direct evidence to suggest that rising BP in children could be owing to increasing prevalence of childhood obesity in the last two decades.[26] These authors argue that studies showing secular trends in rising

Table 2: Prevalence and 95% CIs for BP categories, BMI categories and WC categories

	Number (*N*=335)	Prevalence rate (%)	95% CIs
BP categories			
Normal BP	248	74.1	69.33, 78.73
Pre-hypertension	41	12.2	8.73, 15.75
Grade-1 hypertension	41	12.2	8.73, 15.75
Grade-2 hypertension	4	1.2	0.03, 2.36
BMI categories			
Thinness	48	14.4	10.58, 18.08
Normal	208	62.1	56.89, 67.28
Overweight	38	11.3	7.95, 14.74
Obese	41	12.2	8.73, 15.75
WC categories			
Obese	46	13.7	10.05, 18.08
Not obese	289	86.3	82.58, 89.95

BP: Blood pressure; BMI: Body mass index; WC: Waist circumference; CIs: Confidence intervals; SD: Standard deviation

Table 3: Comparison of prevalence of elevated BP, mean SBP and mean DBP among overweight and non-overweight children

	Elevated BP	Normal BP	Prevalence (%) of elevated BP (95% CIs)	Mean SBP (SD)	Mean DBP (SD)
WHO reference categories†					
Thinness	3	45	6.3 (−0.60, 13.10)	93.60 (8.12)	60.83 (8.95)
Normal	38	170	18.3 (13.02, 23.52)	97.23 (8.74)	65.29 (9.66)
Overweight/obese	33	46	41.8 (30.89, 52.65)	108.28 (11.95)	75.73 (9.56)
WC categories (≥90th percentile)†					
Non-obese	11	248	4.2 (1.79, 6.70)	97.18 (9.09)	65.07 (9.63)
Obese	52	87	37.4 (29.36, 45.45)	112.76 (10.96)	79.96 (8.42)

†P<0.001, BP: Blood pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; WHO: World Health Organization; CIs: Confidence intervals; SD: Standard deviation; WC: Waist circumference

childhood BP concomitant with obesity were lacking. However, a study from India comparing obesity and BP in school children in two different periods did not demonstrate any secular trend for increasing proportion of elevated BP.[28] Low physical activity is not only an independent risk factor for obesity, but is also associated with elevated BP in children.[35] However, in our study, physical activity score was not associated with either SBP or DBP. Research has shown that physical activity of moderate to vigorous intensity for 40 min, 3-5 times a week may decrease BP in obese children.[50] Therefore, experts have suggested that preventive measures should be taken in both schools and the community to counter physical inactivity and childhood obesity.[51] It has been suggested that dietary factors should be assessed in epidemiological studies on childhood BP.[26] In our study,

the intake of cereals was negatively correlated with SBP while non-vegetarian food was positively correlated with SBP on bivariate correlation. However, after adjustment, both factors were not correlated with SBP. There is inconclusive evidence about effect of total sleep duration on BP. A study from Japan reported that the duration of sleep is associated with SBP while a study from India found no such association.[36,37] However, in our study, duration of sleep was negatively correlated with DBP even after adjustment. Future studies should evaluate the relationship of dietary factors, physical activity, and the duration of sleep with BP in children using valid methods of measuring these factors.

CONCLUSION

Mean SBP, mean DBP, and prevalence of elevated BP were higher among overweight and obese children in suburban Malaysia. SBP was associated with both BMI and WC, but DBP was associated with age, BMI, and total hours of sleep. Periodic surveys on obesity and BP in school children should be carried out. Health promotional activities for primordial prevention of CVDs should be done for school children.

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Table 4: Correlation coefficients between BP and BMI, WC, food frequency scores, and physical activity scores

Variable	SBP	DBP
Age	0.051	0.173**
BMI	0.540**	0.544**
WC	0.545**	0.538**
C-PAQ score	0.126*	0.069
Oils and fats	−0.240	−0.101
Sweet foods	−0.107	−0.091
Dairy products	−0.039	−0.045
Cereals	−0.108*	−0.027
Vegetables and fruits	−0.380	−0.052
Non-vegetarian foods	0.124*	−0.086
Total (weekly) hours of sleep	0.090	−0.108*

*$P<0.05$, **$P<0.01$, BP: Blood pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; WC: Waist circumference; C-PAQ: Child physical activity questionnaire

Table 5: Association of SBP and DBP with BMI, WC, food frequency scores and physical activity scores

Variable	Beta-coefficient	Lower 95% CI	Upper 95% CI	*P* value
SBP				
Age	−0.012	−3.910	3.026	0.802
BMI	0.250	0.005	1.501	0.049
WC	0.308	0.071	0.668	0.015
C-PAQ score	−0.052	−2.748	0.814	0.286
FFQ score animal food	−0.028	−0.321	0.188	0.608
FFQ score cereal-based foods	−0.039	−0.399	0.183	0.466
Total (weekly) hours of sleep	−0.071	−1.184	0.136	0.120
DBP				
Age	0.111	0.774	7.656	0.017
BMI	0.320	0.217	1.702	0.012
WC	0.227	−0.025	0.567	0.072
C-PAQ score	−0.013	−1.999	1.535	0.796
FFQ score animal food	−0.048	−0.367	0.138	0.373
FFQ score cereal-based foods	0.042	−0.175	0.402	0.438
Total (weekly) hours of sleep	−0.095	−1.350	−0.041	0.037

BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; WC: Waist circumference; C-PAQ: Child physical activity questionnaire; FFQ: Food frequency questionnaire; CI: Confidence interval

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