UNDERNUTRITION AND ADIPOSITY IN CHILDREN AND ADOLESCENTS: A NUTRITION PARADOX IN BANGLADESH

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Abstract

Many studies reported a high prevalence of undernutrition in the under-5 children in Bangladesh. But very few information are available about undernutrition and adiposity among school children and adolescents in Bangladesh. This study addressed the prevalence of undernutrition and obesity among school going children and adolescents. A total of 15 secondary schools were purposively selected from rural, suburban and urban areas. The teachers were detailed about the study protocol. Then the teachers volunteered to register the eligible (age 10 – 18y) students for the study. Each student's parent was interviewed for family income. Height (ht), weight (wt), mid-upper arm circumference (MUAC) and blood pressure were taken. Fasting blood samples were collected for fasting plasma glucose, total cholesterol (Chol), triglycerides (TG), high-density lipoproteins (HDL). Body mass index (BMI) was calculated (ht/wt in met. sq) for diagnosis of undernutrition (BMI <18.5), normal weight (BMI 18.5 – 22.9) overweight (BMI 23.0 – 25.0) and obesity (BMI >25.0). A total of 2151 (m-1063, f-1088) students volunteered the study. Of them, the poor, middle and rich social classes were 25.4, 53.1 and 21.5%, respectively. Overall, the prevalence of underweight, normal, overweight and obesity were 57.4%, 35.0%, 4.9% and 2.7%, respectively. For gender comparison, there has been no significant difference of BMI between boys and girls. By social class, the prevalence of underweight was significantly higher in the poor than in the rich (62.2% v. 43.6%) and obesity was higher in the rich than in the poor (6.1% v. 1.2%) [for both, p<0.001]. Logistic regression showed that the participants from urban (OR 1.51, 95% CI 1.03 – 2.22) and the rich (OR 2.03, 95% CI 1.24 – 3.33) social class had excess risk for obesity. The risk for undernutrition was found just reverse. Undernutrition was found most prevalent among the rural students and among the poor social class; whereas, prevalence of overweight and obesity appears to be increasing with urbanization and increasing family income. Thus, the study showed a nutrition paradox – adiposity in the midst of many undernourished children and adolescents in Bangladesh. Further study may be undertaken in a large scale to establish diagnostic criteria for age specific nutrition assessment in Bangladesh. A prospective children cohort may help assessing the cut-offs for unhealthy sequels of undernutrition and adiposity.

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Key words: children, undernutrition, obesity, social class, rural, urban

Introduction

Bangladesh is a least developing country and more than one-third of its children are exposed to undernutrition. Undernutrition is also common among the pregnant mothers. Low birth weight was reported

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to be 36%.[1] Thus, these Bangladeshi children experience nutritional deficiency from birth. The prevalence of moderate to severe malnutrition in children (Gomez Classification) was reported to be the same (~36%). The prevalence rates of underweight (weight for age, <2SD), stunting (height for age, <2SD) and wasting (weight for height, <2SD) in children of age 6-71 months were 51.1, 48.8 and 11.7%, respectively.[1] These figures indicate that majority of the children are exposed to undernutrition. Such undernutrition at early life leads to some metabolic disorders in adulthood.[2,3] This has also been reported in other developing communities.[4-6] Interestingly, some observed that the combination of underweight and overweight in children coexist in the same community or even in the same family.[7] This is dubbed as the "dual burden household". It is postulated that a relatively new phenomenon is emerging in the developing countries. It leads to the nutrition transition along with socioeconomic and demographic transition resulting changes in diet, food availability and lifestyle. In Bangladesh too, possibly due to such socio-economic transition and changes in lifestyle, undernutrition and adiposity coexist. This appears to be a nutrition paradox. An awesome undernutrition is now added with obesity– an emerging health problem in children. So far, most of the studies conducted in Bangladesh addressed 'undernutrition in children of age below 71 months'. There has been very few information about childhood nutrition beyond this age group. This study addresses the overall nutritional status among children and adolescents in Bangladesh. Additionally, the study attempts to assess the socio-demographic and socio-economic risks related to both undernutrition and obesity.

Subjects and Methods

Study design

Purposively, we selected secondary schools. The schools from rural, suburban and urban were 8, 2 and 5, respectively. All students of age group 10 to 18 years were considered eligible and enlisted in each school. An attempt was made to maintain population proportion of geographical sites (rural, urban and suburban)[1] with an equal ratio of male and female participants. We discussed the objectives and investigation procedures with the teachers. We sought help from the teaching staff and the students to prepare the list of participants. They gave their assent and prepared the list of eligible participants. At registration, each student was advised to attend the school at 8AM with an overnight fast accompanied by a parent. The parents were interviewed about annual family income in order to classify social class according to income tertile (poor, middle and rich).

After the interview height (ht), weight (wt) and mid-upper arm circumference (MUAC) were taken. Body mass index (BMI= wt in kg/ ht in m.sq.) was calculated. Allowing ten minutes rest, blood pressure (BP) was taken in the right arm in sitting position. A mean of three measurements of BP was accepted. For the female students, a female physician and female associates took anthropometry and BP. Each participant was explained and given a practical demonstration on phlebotomy for blood sample collection. Then, if agreed, five ml of fasting blood sample was drawn for estimation of fasting plasma glucose (FPG), total cholesterol (Chol), triglycerides (TG) and high-density lipoproteins (HDL). Plasma was separated after centrifugation in the field within 2 hours of collection. Then plasma was transported in iced chamber that maintains temperature – 0° to 4 °C for 8h, an adequate time to reach BIRDEM for storage in refrigerator that maintains temperature at – 28 °C. Biochemical tests were carried out in BIRDEM central Lab.

As regards nutritional status, we estimated underweight, normal weight, overweight and obesity with corresponding BMI <18.5, 18.5 – 22.9, 23 – 25 and >25.0 kg/m^2, respectively.[8,9] We used the term adiposity (overweight and obesity) when BMI was found greater than 22.9.

Data analysis

A comparison of biophysical characteristics (ht, wt, BMI, MUAC, SBP DBP, FPG, TG, t-Chol, HDL-c) between male and female students in each age tertile was shown in order to identify the sex differences with advancing age. The differences of these biophysical characteristics were also shown according to geographical sites (rural, suburban, urban) and social class (poor, middle, rich). We used 'unpaired t-test' for comparison of characteristics between boys and girls. The prevalence rates for undernutrition, overweight and obesity were given according to age, sex, area (rural, suburban & urban) and family income (poor, middle, rich social class). A logistic regression

Table-1: *Distribution of student participants according to sex, area and social class.*

Sex	Geographical area				Social class			
	Rural	Suburban	Urban	Total	Poor	Middle	Rich	Total
Boys	376 (35.4)	185 (17.4)	502 (47.2)	1063 (100.0)	257 (25.8)	520 (52.2)	220 (22.1)	997 (100.0)
Girl	424 (39.0)	217 (19.9)	447 (41.1)	1088 (100.0)	251 (25.3)	535 (53.8)	208 (20.9)	994 (100.0)
Both	800 (37.2)	402 (18.7)	949 (44.1)	2151 (100.0)	508 (25.5)	1055 (53.0)	428 (21.5)	1991 (100.0)

Parenthesis indicates percentage

analysis estimated the socio-demographic risk variables taking overweight and obesity (BMI > 22.9) as a dependent variable in different models. The probability less than 0.05 was considered significant. All statistical analyses were performed using SPSS 12.0 software.

Results

A total of 2151 (m-1063, f-1088) students volunteered the study (table-1). The participants from rural, suburban and urban were 800, 402 and 949, respectively. Of them, (53%) were from social middle and 25.5% from social poor class (table-1).

The comparisons of ht, wt, BMI, MUAC, SBP & DBP, FPG, TG, Chol, HDL between male and female students were shown according to age tertile in table-2, to geographical sites in table-3 and to social class in table-4.

For age tertile in table-2, mostly, the mean (SD) values for ht, wt, BMI, MUAC, SBP, DBP and TG were

Table-2: *Comparison of biophysical characteristics between male and female participants according to age-tertile.*

Age Tertile →		**Tertile1** (10 – 12y) (n: m / f = 384 / 444)			**Tertile2** (13 – 14y) (n: m / f = 380 / 359)			**Tertile3** (15-18y) (n: m / f = 291 / 282)		
Variables	**Sex**	**Mean**	**¶SD**	***p***	**Mean**	**SD**	***p***	**Mean**	**SD**	***p***
Height (cm)	M	137	9.7		153	9.2		161	6.7	
	F	138	7.9	*0.001*	146	6.3	*0.001*	149	7.2	*0.001*
Weight (kg)	M	31.4	6.7		43.9	9.2		52.9	9.4	
	F	33.0	6.7	*0.001*	41.6	6.6	*0.001*	45.3	7.9	*0.001*
BMI	M	16.5	2.2		18.6	2.9		20.2	3.1	
	F	17.1	2.4	*0.001*	19.3	2.8	*0.001*	20.2	3.3	*ns*
†MUAC (cm)	M	18.5	2.7		21.9	2.9		23.7	2.6	
	F	19.4	2.7	*ns*	22.3	2.6	*ns*	22.8	3.2	*0.001*
SBP (mmHg)	M	86.9	11.8		98.6	13.4		107	12.4	
	F	89.8	12.4	*ns*	99.7	12.4	*ns*	99.9	11.0	*0.001*
DBP (mmHg)	M	52.7	9.8		59.8	10.3		67.4	10.9	
	F	54.4	10.0	*0.033*	61.5	10.6	*0.033*	65.3	9.5	*0.012*
‡FPG mmol/l	M	4.6	0.91		4.4	0.6		4.8	1.3	
	F	4.5	0.61	*0.047*	4.5	1.0	*0.047*	4.7	0.6	*ns*
Triglycerides	M	100	39.0		100	39.0		115	75.9	
(mg/dl)	F	114	36.7	*0.001*	110	34.7	*0.001*	104	31.4	*0.020*
T-Cholesterol	M	152	34.2		144	32.6		151	41.1	
(mg/dl)	F	151	32.8	*ns*	143	34.4	*ns*	150	37.1	*ns*
High-density	M	47.2	10.3		40.9	12.0		45.3	11.0	
Lipoprotien(mg/dl)	F	46.5	9.7	*0.001*	43.4	9.4	*0.001*	45.8	9.6	*ns*

¶ SD – standard deviation; † MUAC – Mid-upper arm circumference; ‡ FBG- fasting plasma glucose;
P values are given after independent t-*test* between male (M) and female (F) students; ns – not significant

Table 3: *Comparison of biophysical characteristics between male and female participants according to geographical sites.*

		Rural (n: m / f = 374 / 422)			Suburban (n: m / f = 185 / 217)			Urban (n: m / f = 501 / 446)		
Variables	**Sex**	**Mean**	**¶SD**	***p***	**Mean**	**SD**	***p***	**Mean**	**SD**	***p***
Height (cm)	M	151	10.9		150	11.1		148	15.3	
	F	143	7.1	*0.001*	144	7.6	*0.001*	143	10.4	*0.001*
Weight (kg)	M	42.7	9.7		42.6	10.0		40.9	14.1	
	F	39.1	6.8	*0.001*	40.0	7.1	*0.003*	38.5	10.8	*0.003*
BMI	ø M	18.5	2.7		18.7	2.8		18.0	3.5	
	ø F	18.8	2.6	*0.019*	19.0	3.1	*ns*	18.4	3.5	*ns*
†MUAC (cm)	ø M	22.0	2.8		21.7	2.7		20.3	3.9	
	ø F	22.2	2.3	*ns*	22.4	2.4	*0.005*	19.7	3.6	*0.018*
SBP (mmHg)	M	97.3	14.5		95.0	12.9		97.2	16.1	
	F	95.8	12.6	*ns*	95.7	11.7	*ns*	95.6	13.9	*ns*
DBP (mmHg)	M	57.5	10.2		57.6	9.5		61.5	13.4	
	F	58.8	9.9	*ns*	59.4	10.3	*ns*	60.3	12.3	*ns*
‡FPG mmol/l	M	4.3	0.48		4.2	0.5		5.0	1.1	
	F	4.4	0.80	*0.014*	4.4	0.8	*0.036*	4.8	0.5	*0.018*
Triglycerides	M	98.6	31.9		106	49.3		108	63.7	
(mg/dl)	F	109	28.7	*0.001*	118	32.0	*0.004*	106	40.6	*ns*
T-Cholesterol	M	149	34.3		136	31.1		154	37.4	
(mg/dl)	F	146	35.4	*ns*	129	29.8	*0.024*	159	31.6	*0.038*
High-density	M	37.8	9.1		36.9	11.1		52.1	7.5	
Lipoprotien (mg/dl)	F	40.2	6.9	*0.001*	40.4	7.9	*0.001*	52.5	7.9	*ns*

¶ SD – standard deviation; † MUAC – Mid-upper arm circumference; ‡ FBG- fasting plasma glucose;
P values are given after independent t-*test* between male (M) and female (F) students. ns – not significant
ø - Comparisons among the geographical site: The means (SD) of BMI and MUAC were significantly higher ($p<0.05$) in the rural than in the urban students.

found significantly higher in female than male students in the age group 10 – 12y (tertile1); but, with the advancing age these were reversed and found significantly higher in males (15 – 18y, tertile3). FPG, Chol and HDL showed some differences but were inconsistent.

In table 3, all age groups were taken together and the mean (SD) values of height and weight were found significantly higher in male than the female students irrespective of geographical sites though BMI of females was found significantly higher than males only in rural participants. Other biophysical variables (MUAC, blood pressure, lipids) differed between boys and girls but mostly these were not consistent. Interestingly, compared with urban male the rural male students had significantly higher height (151 v. 148 cm), weight (42.7 v. 40.9 kg), BMI (18.5 v. 18.0) and MUAC (22.0 v. 20.3 cm) [for all, $p<0.05$]; whereas, for the females, only MUAC was found significantly higher in rural than urban students (22.2 v. 19.7, $p<0.001$).

Comparison between rural and urban showed that BMI (18.7 v. 18.2, $p<0.01$) and MUAC (22.1 v. 20.0, $p<0.001$) of both sexes (m + F) were significantly higher in the rural than urban [data not shown]. On the contrary, DBP (61 v.58 mmHg, $p<0.001$), FPG (4.9 v. 4.4 mmol/l, $p<0.001$), T-cholesterol (157 v. 148 mg/dl, $p<0.001$) and HDL-cholesterol (52.3 v. 39.1 mg/dl, $p<0.001$) of both sexes were found significantly higher in urban than the rural participants [not shown in table]. It may be noted that height, weight, SBP and TG of both sexes did not differ between rural and urban.

Comparisons of the same biophysical variables between male and female participants of different social class were shown in table 4. Compared with female the male students had significantly higher height and weight

Table 4: *Comparison of biophysical characteristics between male and female participants according to social class.*

Social class →		Poor (n: m / f = 255 / 250)			Middle (n: m / f = 520 / 534)			Rich (n: m / f = 219 / 208)		
Variables	**Sex**	**Mean**	**¶SD**	***p***	**Mean**	**SD**	***p***	**Mean**	**SD**	***p***
Height (cm)	M	149	11.4		147	13.2		153	14.2	
	F	141	8.6	0.001	142	8.5	0.001	146	7.3	0.001
Weight (kg)	M	40.4	9.4		39.6	11.5		46.7	14.1	
	F	36.6	7.2	0.001	37.7	8.2	0.003	41.9	9.2	0.001
BMI	ø M	17.9	2.4		17.87	2.9		19.4	3.8	
	ø F	18.1	2.7	ns	18.4	2.9	0.003	19.3	3.4	ns
†MUAC (cm)	ø M	21.1	3.0		20.5	3.4		21.9	3.7	
	ø F	20.8	3.0	ns	20.9	3.3	0.05	21.8	3.1	ns
SBP (mmHg)	M	95.9	12.8		94.7	15.0		99.7	16.5	
	F	93.1	11.7	0.009	93.9	12.6	ns	97.9	12.4	ns
DBP (mmHg)	M	58.1	10.5		57.3	11.3		62.9	13.1	
	F	56.5	10.1	ns	57.9	10.8	ns	62.0	9.8	ns
‡FPG mmol/l	M	4.5	1.1		4.5	0.59		4.8	0.77	
	F	4.5	1.2	ns	4.5	0.61	ns	4.7	0.60	ns
Triglycerides	M	100	36.6		103	42.3		114	74.8	
(mg/dl)	F	112	33.1	0.001	111	35.9	0.001	113	31.1	ns
T-Cholesterol	M	145	34.7		147	35.4		155	35.4	
(mg/dl)	F	146	32.7	ns	148	35.7	ns	146	37.1	.006
High-density	M	41.2	10.8		43.6	11.9		47.9	10.3	
Lipoprotien (mg/dl)	F	43.5	11.3	0.018	45.3	9.28	0.013	44.6	14.2	.001

¶ SD – standard deviation; † MUAC – Mid-upper arm circumference; ‡ FBG- fasting plasma glucose;
P values are given after independent t-*test* between male (M) and female (F) students. ns – not significant
ø - Comparisons among the social class: The means (SD) of BMI and MUAC were significantly higher in the rich ($p<0.05$) than in the poor and the middle class and found significant both for boys and girls.

irrespective of social class. Other variables showed some differences but the difference were inclusive. Compared with poor social class all variables (ht, wt, BMI, MUAC, SBP, DBP, FPG, Chol, TG, HDL) of both sexes (M + F) were found significantly higher in the rich [not shown in table].

The prevalence of underweight and adiposity (overweight and obesity) by social class were presented in table 5. Overall, the prevalence of underweight (BMI=<18.5) was 57.4% and adiposity (overweight + obesity) was 7.6%. The prevalence of adiposity was found mostly in the middle and rich class, and underweight was most prevalent in the middle and the poor class. Thus, middle class was found to have undernutrition (32.2%) and adiposity (3.7%). Obviously, nutrition status was found related to the gradient across social class – undernutrition among the poor and overweight or obesity among the rich (Chi sq 6.8, $p<0.001$).

The percentiles for underweight, overweight, and obesity corresponding to BMI of 18.5, 23.0, and 25.0 kg/m² at age 18 were the 57.5th percentile, the 92.4th percentile, and the 97.3rd percentile, respectively. The corresponding prevalence rates of underweight, overweight, and obesity were 57.4, 4.9, and 2.7%, respectively.

If we accept 15th, 85th and 95th percentile of BMI as underweight, overweight and obesity then BMI cut-offs of these participants would be 15.6, 21.4 and 24.0, respectively.

Finally, a logistic regression estimated the socio-demographic risk factors for adiposity (overweight + obesity) (table 6). Four models were constructed taking

Table 5: *Distribution of underweight and adiposity according to social class*

BMI	Social Class* Poor	Middle	Rich	Total
i) <18.5 (underweight)	314 (15.8)	639 (32.2)	186 (9.4)	1139 (57.4)
ii) 18.5 – 22.9 (normal)	169 (8.5)	343 (17.3)	184 (9.3)	696 (35.0)
iii) Adiposity (=>23.0)	22 (1.1)	72 (3.7)	57 (2.9)	151 (7.6)
a. 23.0 – 25.0 (overweight)	16 (0.8)	51 (2.6)	31 (1.6)	98 (4.9)
b. >25.0 (obese)	6 (0.3)	21 (1.1)	26 (1.3)	53 (2.7)
All	505 (25.4)	1054 (53.1)	427 (21.5)	1986 (100.0)

Parenthesis indicates percentage *Chi sq = 31.2, p<0.001

adiposity (BMI >22.9) as a dependent variable and sex, area, social class and age-tertile as the independent variables in different models. Single independent variable (sex) was taken in model-1. Model-2 included sex and area. Social class and age included in the subsequent models. Thus, all risk variables were included in model-4. The urban students had excess risk (OR 1.51, 95% CI 1.03 – 2.22) for obesity. Regarding social class, taking the poor as reference category the rich had excess risk (OR 2.03, 95% CI 1.24 – 3.33). Finally, compared with low age quartile (reference <12y) the upper quartiles were proved to have significant risks with the advancing age.

Logistic regression was also used to quantify the predictors of undernutrition taking BMI <18.5 as a dependent variable (data not shown). The poor social class and the rural area were found to be the independent risks for underweight.

Table 6: *Binary logistic regression risk factors selected at different models taking adiposity (BMI>22.9) as a dependent variable.*

Risk factors	Mode l		Mode 2		Mode 3		Mode 4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Sex								
Male	1	–	1	–	1	–	1	–
Female	1.09	0.82-1.45	1.12	0.84-1.48	1.05	–0.77-1.42	1.17	0.86-1.61
Area								
Rural			1	–	1	–	1	–
Suburban			1.48	0.99-2.20	1.43	0.95-2.13	1.38	0.92-2.08
Urban			1.39*	1.00-1.93	1.07	0.75-1.53	1.51*	1.03-2.22
Social class								
Poor					1	–	1	–
Middle					1.61*	1.04-2.51	1.54	0.98-2.42
Rich					3.25***	2.04-5.18	2.03**	1.24-3.33
Age								
≤ 12.0							1	–
12.0-14.0							5.97***	3.32-10.76
14.0-16.0							9.35***	5.14-17.03
>16.0							22.93***	11.79-44.57

*p<0.01, **p<0.001, ***<0.0001

Discussion

The study was first of its kind to address nutritional status among Bangladeshi children and adolescents (10 – 18y) in three geographical sites (rural, suburban, urban). The information of annual family income, though difficult, was collected from the parents for socio-economic grading into major classes of poor, middle and rich. Thus, it was possible to determine the association of nutrition with the social class and geographical sites. The values for anthropometry, blood pressure, fasting plasma glucose and lipids were given separately and elaborately according to age-tertile, sites and social class for comparison between male and female participants in order to provide the age-, sex- and site-specific data for future references. The study has an additional strength that the participants from sex, social class and geographical sites conforms the Bangladeshi population statistics.[1]

The study has several limitations. Firstly, central obesity (waist/hip) and skin-fold thickness were not taken. So, fat patterning of this age group could not be assessed. Secondly, assessment of dietary intake and physical activity were not included in the study. These information could have improved the study.

According this study, the percentiles for underweight, overweight, and obesity corresponding to BMI of 18.5, 23.0, and 25.0 kg/m^2 of age 12 – 18 years were the 57.5th percentile, the 92.4th percentile, and the 97.3rd percentile, respectively. The corresponding prevalence rates of underweight, overweight, and obesity were 57.4, 4.9, and 2.7%, respectively. For comparison, the anthropometric measures of this age group in Bangladesh and in the neighboring countries are not available so far. In Sri Lanka, a nutrition study among children of age 8-12 years showed that the prevalence of obesity in boys was 4.3% and in girls was 3.1%.[9] In Sri Lankan students, thinness was 24.7% in boys and 23.1% in girls. So, our children had more undernutrition than that of Sri Lanka though obesity was somehow lower.

Very similar study was reported from south Korea that the percentiles for underweight, overweight, and obesity corresponding to BMI of 18.5, 23.0, and 25.0 kg/m^2 at age 18 were the 13.0th percentile, the 77.8th percentile, and the 91.2nd percentile, respectively.[10] The corresponding prevalence of underweight, overweight, and obesity were 12.1, 12.5, and 9.8%, respectively. So, large proportions (57.5%) of our children were underweight as compared with the Sri Lankan and Korean children.[9,10]

In contrast, in New York City elementary school students, the prevalence of obesity was found 24%.[11] They found that the Asian children had the lowest level of obesity among all racial/ethnic groups (14.4%). Not only in New York, the prevalence of obesity among Asians was also found lowest in Texas (11%).[12] Thus, it appears that the Bangladeshi children, by ethnicity, are resistant to overweight. Or, it may also be true that the definition of underweight or obesity might have other cut offs for BMI. If we accept 15th, 85th and 95th percentile of BMI as underweight, overweight and obesity then BMI cut-offs would be 15.6, 21.4 and 24.0, respectively.

Conclusions

We conclude that the prevalence of underweight among children and adolescent still remains high and related mainly to poor and partly to middle socio-economic class irrespective of geographical sites. The prevalence of adiposity (overweight and obesity) appears to be high among the rich, moderate among the middle and very low among the poor social class. The urban students of both sexes have excess risk for overweight and obesity. Thus, the children and adolescent of Bangladesh showed a nutrition paradox – adiposity coexists with prevalent undernutrition. Further study may be undertaken to determine nutritional status in relation with dietary intake, physical activity and fat distribution. Finally and importantly, we need to define underweight, overweight and obesity for Bangladeshi population for specific age groups.

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