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Isezuo KO
Jiya NM
Audu LI
Ibitoye PK
Sani UM
Ahmad MM
Garba BI
Waziri UM

Body mass index assessment using three reference standards among school adolescents in Sokoto Metropolis, North-Western Nigeria

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Isezuo KO (✉)
Jiya NM, Ibitoye PK, Sani UM
Ahmad MM, Garba BI, Waziri UM
Department of Paediatrics,
Usmanu Danfodiyo University
Teaching Hospital, Sokoto, Nigeria
Email: khadisez@yahoo.com

Audu LI
Department of Paediatrics,
National Hospital, Abuja, Nigeria

Abstract*: Background:* Under nutrition and overweight in children co-exist in developing countries and may persist into adulthood. Interpretation of body mass index (BMI), a useful measure of nutritional status in children requires age related reference standards, many of which were developed from different international sources. It is necessary to determine which of these reference standards is most suitable for use in the assessment of BMI distribution among adolescents in Nigeria.

Objective: To determine the prevalence of thinness, overweight and obesity using the World Health Organization (WHO), International Obesity Task Force (IOTF), and Centre for Disease Control (CDC) reference standards and assess their level of agreement amongst adolescents in Sokoto metropolis.

Methods: 800 students were selected through multi-stage sampling technique from secondary schools. BMI was classified according to three reference standards (WHO, CDC, IOTF). Data was analysed with SPSS version 22. The level of agreement between the reference standards in diagnosing nutritional status was assessed using Kappa statistics. Level of significance was put at $p< 0.05$.

Results: The prevalence rate of thinness was highest with the IOTF at 22.6% compared to 19.4%, and 19.6% by the WHO and CDC respectively. The prevalence rates of overweight and obesity were highest with the WHO reference standards at 7.0% and 1.3% followed by the IOTF (6.1% and 0.6%) and lowest with the CDC (5.8% and 0.3%). Substantial agreement was observed between WHO and IOTF (Kappa = 0.77), while the level of agreement was 0.68 for IOTF/CDC and 0.64 for WHO/CDC. All agreement statistics were significant ($p < 0.001$).

Conclusion: The WHO and IOTF reference charts may be more suitable for our population.

Key words: body mass index, WHO, IOTF, CDC, Sokoto, adolescents

Introduction

Under nutrition and overweight in children are both prevalent in developing countries. This nutrition paradox occurs because of social inequalities and rapid epidemiological transition.[1] Under nutrition in children especially if severe can lead to problems such as poor resistance to infection, cognitive problems and also contributes to morbidity and mortality from other illnesses.[2,3] Obesity leads to many physical and psychosocial complications which also persist into adulthood and reduce the quality of life if not addressed.[2,3]

Body mass index (BMI), is a widely accepted and affordable proxy measure to assess nutritional status in children but requires age related references often developed from different international sources.[4] Nutritional disorders of childhood may persist into adulthood leading to increased morbidity, mortality and reduced life expectancy hence, early detection is vital to ameliorate associated complications.[3]

The most widely used references for nutritional status assessment in children and adolescents are the Centres for Disease Control and Prevention (CDC) reference which was developed in 2000 from five previous nationally representative surveys of American children,[5] the International Obesity Task Force (IOTF) reference de-

veloped in 2005 by experts, who extrapolated the adult BMI cut-off points for overweight (25 kg/m^2) and obesity (30 kg/m^2) to data sets from six countries,[6] which were later extended to include cut offs for thinness in 2012,[7]and the WHO criteria developed in 2007 from child's growth data from the United States National Centre for Health Statistics and data from six countries.[8] These reference standards were developed for different reasons from different reference populations; therefore, they give different prevalence rates of childhood BMI status. It is necessary to compare their performance to ensure proper use in populations of children likely to exhibit anthropometric parameters different from reference population. A previous study in Port Harcourt,[9] in Southern Nigeria compared the three references among female adolescents only and this may not be reflective of both genders. Hence, the current study was carried out to compare the various growth reference standards/values in the assessment of BMI status among adolescents in Sokoto, an urban centre in Northern Nigeria where no such study has been done previously.

Objectives

To determine the prevalence of thinness, overweight and obesity using the World Health Organization (WHO), International Obesity Task Force (IOTF), Centre for Disease Control (CDC) reference standards amongst secondary school students aged 10 to 18 years in Sokoto metropolis and to assess the level of agreement between these reference standards in determining BMI status.

Subjects and Methods

Study location

The study was carried out in Sokoto, the capital of Sokoto State of Nigeria. The city lies on latitude 13º3′5″ N and longitude 5º15′53″E of the Equator.[10] The projected population of the city in 2015(from 2006 census figures) is 558,130at an annual growth rate of 3%.[11] The three Local Government Areas (LGA) which constitute the metropolis, are Sokoto North, Sokoto South and Wammako. Inhabitants are mainly ethnic Hausa and Fulani but many other ethnic groups also reside in the State. All the socioeconomic classes are represented in the population.

Study Population

The study population were students aged 10 to 18 years from secondary schools in Sokoto Metropolis.

Study design

The study was descriptive and cross-sectional in design.

Sample size determination

Sample size was calculated using the formula

$$n = z^2pq/ d^2$$

Where n = minimum sample size

z = Standard normal deviate set at 1.96

p = There was no previous study in this North western region of Sokoto and environs.

Therefore, a prevalence of 50% (0.5) was used.[12]

q = 1 - p = 1 – 0.5 = 0.5

d = degree of accuracy desired = 0.05

A minimum sample size of 384 was arrived, however, about 800 participants were sampled to increase the chances of statistically valid results.

Sample selection

The study participants were selected through a multistage sampling process from the secondary schools in the Metropolis which is made up three LGAs. Two schools were selected from each LGA to give six schools. Proportionate numbers of subjects were allocated to each school based on their population. The allocated number to each school was further divided proportionately amongst six class levels [Junior Secondary (1-3) to Senior Secondary(1-3)] in each school. In each class, the allocated number was drawn by simple random sampling.

Inclusion and exclusion criteria

All the subjects who assented and whose parents gave written informed consent were included. Those excluded were subjects with history and clinical signs of acute and chronic illnesses that could affect cause significant weight loss, those with oedema and those on drugs that could cause weight gain like steroids. Also, those with gross limb abnormalities were excluded as these would affect the BMI calculated.

Data collection tools

A structured questionnaire was used to record each subject's demographic data, weight and height measurements. A Camry Electronic Weighing Scale (Model EB 1002. ISO 9001: 2008) and Stature Meter Bioplus^R (Model number 26M/ 1013522; Bharat Enterprises) were used to obtain the weights and height respectively after proper standardization. The Body mass index charts for CDC, IOTF, and WHO were used.

Measurements

Weight was measured with a battery powered electronic weighing scale. The batteries were changed daily to ensure consistent results. Subjects were weighed lightly dressed in school uniform without shoes, stockings, caps, veils, sweaters or jackets, and all pockets were emptied. Measurements were taken to the nearest 1g.

Height was measured with a Stature Meter, which was mounted on a flat wall surface to nearest 0.1cm. After removal of all footwear and caps, subjects stood erect with their heels, buttocks, shoulders and occiput against the wall, so that the external auditory meatus and lower border of the eyes were in the same horizontal plane.

Body mass index was derived from the weight (kg) and height (m) for each subject, using the formula: BMI =

Weight (kg) / Height (m^2).
BMI values were classified according to three reference standards (WHO, CDC, IOTF) as follows:
WHO: BMI for age < 5th percentile as Thinness, > 5th to < 85th percentile as Normal, between 85th to 97th percentiles as Overweight and above 97th percentile as Obesity.[8]
CDC: BMI for age < 5th percentile as Thinness, > 5th to < 85th percentile as Normal, between 85th to 95th percentiles as Overweight and above 95th percentile as Obesity.[5]
IOTF: Thinness is defined as BMI of ≤ 18.5Kg/m^2, Normal as BMI of >18.5 to < 25kg/m^2 and Overweight as BMI of ≥25kg/m^2 and Obesity as BMI of ≥ 30kg/m^2.[7]
Socio-Economic classification was based on the method described by Oyedeji.[13] Scores were awarded to each child based on the occupation and educational attainment of the parents or their caregivers.

Ethical approval

Ethical approval for the study was obtained from the Ethics Committee of Usmanu Danfodiyo University Teaching Hospital, Sokoto. Approval was obtained from the Ministry of Education of Sokoto State. Principals and teachers of participating schools gave permission for the conduct of the study in their schools. Written consent was obtained from the parents or caregivers of the participating students. Assent was obtained from the participating students.

Statistical analysis

Data entry and analysis was done using statistical package for social sciences (SPSS) version 22.0. (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, NY, USA). Continuous variables were presented as means and standard deviations. Categorical variables were presented as percentages and distribution of BMI status determined by the different reference standards were compared using Chi squared test.
The level of agreement between the reference standards in diagnosing nutritional status was assessed using Kappa statistics. According to Cohen,[14] kappa coefficients between 0.1 and 0.20 indicate slight agreement, between 0.21 and 0.40 are considered as fair, between 0.41 and 0.60 as moderate, between 0.61 and 0.80 as substantial, and between 0.81 and 1 as almost perfect.
Multivariate logistic regression analysis was carried out to assess the variables that predict the probability of being overweight or obese according to the three BMI references. The dependent variable was BMI status dichotomously classified as not overweight (thin and normal) and overweight (overweight and obese). The independent variables entered into the model were those that were significantly related to BMI status on bivariate analysis (Chi-square). For all analysis done, p value less than 0.05 was considered statistically significant.

Results

Socio-demographic characteristics

Of the 800 subjects, 424 (53.0%) were males (M:F ratio-1.1:1) and 565 (70.6%) were from public schools. The mean age was 14.5 ± 2.0 years (95% CI = 14.3 – 14.6 years). Mid adolescents within the age range of 14 to 16 years accounted for 48.1%, followed by early adolescents aged 10 to 13 years (34.0%), then late adolescents aged between 17 to 18 years (17.9%). Those from lower socio-economic class were in the majority; accounting for 376 (47%).

Prevalence of thinness, underweight and obesity according to the three reference systems

In Table 1, BMI classification according to the different references is shown. Thinness was the most prevalent abnormality in the population according to all the references. The IOTF criteria yielded the highest prevalence of thinness. The WHO criteria yielded the highest prevalence of overweight (7.0%) and obesity (1.3%) followed by the IOTF(6.1%, 0.6%), then the CDC (5.8%, 0.3%) as seen in Figure 1.

Table 1: BMI Classification according to WHO, IOTF and CDC references

	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)
*WHO**				
Male	112 (26.4)	282 (66.5)	27 (6.4)	3 (0.7)
Female	43 (11.4)	297 (79.0)	29 (7.7)	7 (1.9)
Total	155 (19.4)	579 (72.4)	56 (7.0)	10 (1.3)
*IOTF***				
Male	125 (29.5)	278 (65.6)	21 (5.0)	0 (0.0)
Female	56 (14.9)	287 (76.3)	28 (7.4)	5 (1.3)
Total	181 (22.6)	565 (70.6)	49 (6.1)	5 (0.6)
*CDC****				
Male	108 (25.5)	299 (70.5)	17 (4.0)	0 (0.0)
Female	49 (13.0)	296 (78.7)	29 (7.7)	2 (0.5)
Total	157 (19.6)	595 (74.4)	46 (5.8)	2 (0.3)

* X^2 = 30.0, df = 3, p = 0.00, ** X^2 = 29.7, df = 3, p = 0.00, *** X^2 = 24.5, df = 3, p = 0.00

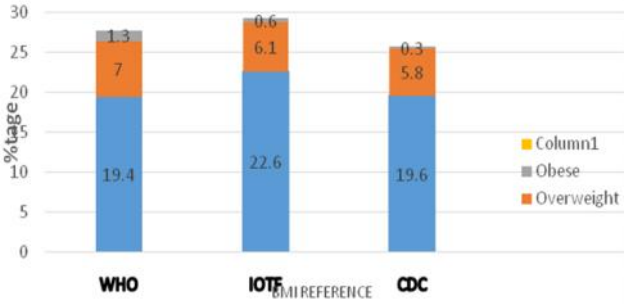
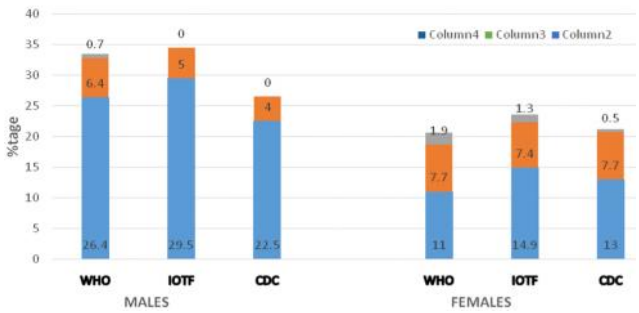


Fig 1: Showing the prevalence of thinness, overweight and obesity

When analysed by gender, it was seen that thinness was higher in males while overweight and obesity was higher in females across the three references shown in Figure 2 (p < 0.001). None of the males was obese according to the IOTF and CDC references

Fig 2: Showing the prevalence of thinness, overweight and obesity by gender



In Table 2, all the three references showed that prevalence of overweight was highest amongst the mid-adolescents aged 14 to 16 years, while obesity was higher amongst the late adolescents. The prevalence of thinness was highest using the IOTF amongst the mid-adolescents, while the WHO and CDC references yielded highest prevalence of thinness in the early adolescents and late adolescents respectively

Table 2: BMI Classification by age according to WHO, IOTF and CDC references

	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)
WHO*				
10 – 13	54 (19.9)	196 (72.1)	16 (5.9)	6 (2.2)
14 – 16	73 (19.0)	277 (71.9)	35 (9.1)	0 (0.0)
17 – 18	28 (19.6)	106 (74.1)	5 (3.5)	4 (2.8)
Total	155 (19.4)	579 (72.4)	56 (7.0)	10 (1.3)
IOTF**				
10 – 13	57 (21.0)	199 (73.2)	14 (5.1)	2 (0.7)
14 – 16	93 (24.2)	263 (68.3)	29 (7.5)	0 (0.0)
17 – 18	31 (21.7)	103 (72.0)	6 (4.2)	3 (2.1)
Total	181 (22.6)	565 (70.6)	49 (6.1)	5 (0.6)
CDC***				
10 – 13	53 (19.5)	204 (75.0)	15 (5.5)	0 (0.0)
14 – 16	71 (18.4)	288 (74.8)	26 (6.8)	0 (0.0)
17 – 18	33 (23.1)	103 (72.0)	5 (3.5)	2 (1.4)
Total	157 (19.6)	595 (74.4)	46 (5.8)	0 (0.3)

* X^2 = 15.1, df = 6, p = 0.02, **X^2 = 11.3, df = 6, p = 0.08, ***X^2 = 12.4, df = 6, p = 0.05

In Table 3, the BMI classification according to social class is shown. The lower social class accounted for a higher prevalence of thinness regardless of the BMI classification used. While the upper social class accounted for a higher proportional prevalence of obesity and overweight with all the classifications except for the CDC classification where obesity was only seen in the lower social class. However, all the findings were significant (p < 0.001).

Table 3: BMI Classification (WHO, IOTF and CDC) in relation to social stratification

Social stratification	Thin n (%)	Normal n (%)	Over-weight n (%)	Obese n (%)
WHO*				
Upper	23(14.4)	107 (66.9)	22 (13.0)	8 (5.0)
Middle	19 (17.2)	226 (85.6)	19 (7.2)	0 (0.0)
Lower	113 (30.1)	246 (65.4)	15 (4.0)	2 (0.5)
Total	155 (19.4)	579 (72.4)	56 (7.0)	10 (1.3)
IOTF**				
Upper	26 (16.3)	107 (66.9)	24 (15.0)	3 (1.9)
Middle	28 (10.6)	220 (83.3)	16 (6.1)	0 (0.0)
Lower	127 (33.8)	238 (63.3)	9 (2.4)	2 (0.5)
Total	181 (22.6)	565 (70.6)	49 (6.1)	5 (0.6)
CDC***				
Upper	26 (16.3)	111 (69.4)	23 (14.4)	0 (0.0)
Middle	26 (9.8)	224 (84.8)	14 (5.3)	0 (0.0)
Lower	105 (27.9)	260 (69.1)	9 (2.4)	2 (0.5)
Total	157 (19.6)	595 (74.4)	46 (5.8)	0 (0.3)

* X^2 = 92.0, df = 6, p = 0.00, **X^2 = 84.0, df = 6, p = 0.00, ***X^2 = 63.2, df = 6, p = 0.00

Agreement level between the three reference systems using Kappa statistics

Substantial agreement was observed between all the references, however this was highest between WHO and IOTF (Kappa = 0.77), while IOTF/CDC was 0.68, and WHO/CDC was 0.64. All were significant (p < 0.001). The details are shown in Table 4.

Table 4: BMI Classification by age according to WHO, IOTF and CDC references

		Thin	Normal	Over-weight	Obese
			WHO		
Thin		142	39	0	0
Normal	IOTF	13	533	19	0
Overweight		0	7	37	5
Obese		0	0	0	5
Level of agreement: kappa statistic: 0.77,p <0.001					
			WHO		
Thin		118	39	0	0
Normal	CDC	37	531	27	0
Overweight		0	9	29	8
Obese		0	0	0	2
Level of agreement: kappa statistic: 0.64,p <0 .001					
			IOTF		
Thin		120	37	0	0
Normal	CDC	61	526	8	0
Overweight		0	2	41	3
Obese		0	0	0	2
Level of agreement: kappa statistic: 0.68,p <0.001					

Multivariate logistic regression analysis of factors associated with overweight and obesity

On multivariate logistic regression analysis, a model was built with BMI status as the dependent variable and age, gender and social class (which were significant on bivariate analysis) as the independent categorical variables. It is seen that those of upper social class were 5 to 7 times more likely to be overweight or obese compared

to the lower social class after controlling for other factors (age, gender). This was statistically significant (<0.001). The result was similar for all the BMI reference standards but the odds of upper social class being overweight or obese was highest with the IOTF reference standard. The result is shown in Table 5.

Table 5: Multivariate logistic Regression Analysis

	Regression coefficient (β)	p-value	Odds ratio	95% confidence interval for odds ratio
WHO				
Age(14-16yr)	0.31	0.43	1.364	0.628 to 2.963
Gender (male)	-0.13	0.63	0.877	0.518 to 1.484
Social class I	1.648	<0.001	5.197	2.704 to 9.991
Social class II	0.479	0.165	1.615	0.821 to 3.175
IOTF				
Age (14-16 yr)	0.04	0.92	1.042	0.468 to 2.319
Gender (male)	-0.43	0.16	0.653	0.362 to 1.177
Social class I	2.003	<0.001	7.409	3.476 to 15.79
Social class II	0.757	0.06	2.13	0.97 to 54.682
CDC				
Age (14-16 yr)	0.19	0.67	0.666	0.255 to 1.743
Gender (male)	-0.6	0.07	1.210	0.503 to 2.913
Social class I	1.745	<0.001	5.724	2.643 to 12.396
Social class II	0.601	0.15	1.823	0.812 to 4.093

Discussion

Thinness was the most prevalent abnormality probably reflective of the fact that a higher proportion of the population were of the lower social class and subject to chronic undernourishment. Thinness was also the most prevalent in the study by Ejike et al in Umuahia[15] southeast Nigeria but overweight was the prominent abnormality in the study by Jaja and Alex-Hart[9] from Port Harcourt also in southern Nigeria. This may be explained by the fact that the Port Harcourt study was only conducted amongst females who were from a cosmopolitan area and were more likely to be overweight. Other studies from Canada and Brazil reported overweight as the more prevalent abnormality in adolescents.[16,17]

The WHO reference standard yielded a higher prevalence of overweight and obesity in this study compared to the IOTF and CDC references. The WHO reference also yielded a higher prevalence of overweight and obesity compared to the other two references in studies from Southern Nigeria by Ejike et al[15] and Jaja and Alex-Hart.[9] Similar results were also reported by Gonzalez[18] and Banjade[19] from Colombo and India respectively. The reason for this could be that the WHO reference includes more data from developing countries. Rehman[20] reported that the WHO reference affords earlier diagnosis of obesity because the data was derived from a non-obese population before the onset of the obesity epidemic.

The IOTF criteria yielded a higher prevalence of thinness in this study which was also similar to results from Port Harcourt and Umuahia.[9,15] Among Brazilian adolescents in a study by Minghelli,[17] the WHO reference gave a higher prevalence of thinness followed by the IOTF reference. Lopes[21] and de Moraes[22] also found thinness was higher using the IOTF criteria in Portugal and Brazil. One reason that has been adduced to the higher yield of thinness by the IOTF reference is that the countries from which the reference population used was drawn, have a Gross Domestic Product (GDP) which is higher than the world average.[9] Therefore, when used to assess subjects from less endowed countries, it may overestimate the prevalence of underweight in these populations. The CDC reference gave the lowest prevalence of overweight and obesity in this study. This may not be surprising considering that the data used to derive the reference was drawn from only the United States as compared to the more inclusive nature of the other references.

Prevalence of overweight and obesity was higher in females than males using all the criteria. In the studies by Gonzalez et al[18] and Banjade et al[19] females had higher prevalence of overweight, however the males were more obese only with the use of CDC criteria. It has been observed that in developing countries, female adolescents are usually more overweight or obese than their male counterparts while in developed countries, males are equally or may be more affected. The risk factors for obesity including ingestion of high caloric diets, sedentary lifestyle in addition to increase screen time either with television and other electronic devices are all higher in developed countries and may account for this.[15] Also, female adolescents participate less in outdoor activities and exercise than their male counterparts in developing countries and this may also be contributory. Additionally, female adolescents also tend to be more conscious of their weight with higher prevalence of eating disorders aimed at losing weight amongst them in developed countries.[23,24] For the age distribution, it was seen that overweight was more prevalent among the mid-adolescents, while obesity was more in the older adolescents. This finding may be related to pubertal growth and development.

WHO estimates that three-quarters of all deaths in the developing world by the year 2020 will be due to non-communicable diseases (NCDs).[25] Underweight and overweight are NCDs in childhood that are associated with inherent complications and may adversely influence the manifestation of other diseases.[3] The magnitude of these problems can be determined by the BMI status of the population to ascertain the prevalence, trends and determinants of any abnormality detected. This is necessary so as to effectively design public health interventions.

When assessing BMI-for-age, it is important that the available reference systems are compared to ascertain which may be more suitable for a particular population. The IOTF cut-offs are recommended for researchers and policy makers in different countries for descriptive and comparative purposes while the CDC Growth Charts and WHO charts are intended for clinical use in moni-

toring children's growth.[5,6,8] However, all three systems are being used in practice for research purposes and there is no perfect reference system which may be suitable globally.

In this study, there was more agreement between the WHO and IOTF, while there was more agreement between the WHO and CDC in the study by Jaja and Alex-Hart[9] and in the study from India by Banjade et al.[19] Other studies from Canada and Portugal showed there was more agreement between the CDC and IOTF references compared to the WHO in studies.[16,17] There was more agreement between the WHO and IOTF references in our study probably because these two references cut across different populations and would likely give a truer prevalence of BMI status than the CDC reference which was only drawn from American children. Despite the variations in prevalence of thinness, overweight and obesity, there was a good agreement among the three references in this study.

Results from our study also indicated that those of higher social economic class were more likely to have combined overweight and obesity compared to the lower social class, similar to results from the studies by Gonzalez[18] and van Vliet.[26]. Though nutrient intake and level of physical activity were not assessed, those of higher social class are more likely to indulge in fast foods and less likely to participate in daily exercises like trekking to school, therefore may be more prone to overweight.[27] However, in some populations, especially in developed countries with large slums, those of lower social class have been found to be more overweight, due to poor feeding practices and lack of areas for exercise.[28,29] Generally, indulgence in junk food which have high caloric content and insufficient physical activity, behaviours that are learned in childhood, are major contributors to obesity and its resulting health problems.[30]

A limitation of the study was that there was no comparison to any standard measurement of body fat. Also, we did not explore the relationship of BMI distribution with ethnicity because a significant proportion of the study population were of the Hausa-Fulani extraction. With respect to BMI distribution with ethnicity, further studies are needed in other parts of Nigeria for comparison.

Conclusion

It is concluded that thinness was more prevalent in the study population, and the WHO and IOTF reference charts may be more suitably applied to adolescents from Nigeria since they may permit earlier diagnosis of under and over-nutrition.

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