Eleven-year Prevalence Trends of Obesity in Greek Children: First Evidence that Prevalence of Obesity Is Leveling Off

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We examined 11-year (1997–2007) trends in underweight, overweight, and obesity in Greek children. Population data derived from a yearly, school-based health survey carried out between 1997 and 2007 in >80% of all Greek schools. Height and weight measurements from 651,582 children, aged 8–9 years (boys: 51.2%) were analyzed. The gender- and age-specific BMI cutoff points by the International Obesity Task Force (IOTF) were used in order to define underweight, normal weight, overweight, and obesity. Trend analysis showed an increase in the prevalence of obesity from 7.2 ± 0.2% in 1997 to 11.3 ± 0.2% in 2004 for girls ($P < 0.001$) and from 8.1 ± 0.2% in 1997 to 12.3 ± 0.2% in 2004 for boys ($P < 0.001$). An apparent leveling off in obesity rates was observed during 2004–2007 for both boys and girls. The prevalence of overweight rose between 1997 and 2007 from 20.2 ± 0.2% to 26.7 ± 0.2% for girls ($P < 0.001$) and from 19.6 ± 0.2% to 26.5 ± 0.2% for boys ($P < 0.001$). The overall prevalence of thinness in the same period remained constant in both sexes. The presented population-based data revealed that the prevalence of overweight and obesity among 8- to 9-year-old Greek children is alarmingly elevated, with the overweight rates rising continuously. However, an apparent leveling off in obesity rates for the past 4 consecutive years was documented for the first time in both genders.

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INTRODUCTION

The worldwide prevalence of obesity has reached alarming levels. More than 1 billion adults are overweight, of which 300 million are considered clinically obese. Moreover, it is estimated that worldwide over 22 million children under the age of 5 are severely overweight (1). The latter implies that 1 out of 10 children around the world is overweight. Predictive models suggest that the ratio of obese-to-thin children will continue to rise in the future (1). If no action is taken to counteract the trend, the number of overweight children in the European Union is expected to rise by 1.3 million per year, with >300,000 of them becoming obese each year (2). According to the aforementioned trends, childhood obesity has been recognized as an epidemic in most developed and developing countries (3,4). It is now evident from many prospective studies that childhood obesity is associated with adult excess weight status (5). Childhood obesity has also been associated with the development of metabolic syndrome, diabetes, and cardiovascular diseases in later life (6). Moreover, obesity in early life influences social and psychological functioning of children (7).

Despite the alarming rates of obesity reported from several countries, there is a lack of long-term epidemiologic data regarding obesity status of children, especially in Eastern European and Mediterranean countries, including Greece. To the best of our knowledge, only few studies (8–12) have estimated the prevalence of childhood obesity in Greece; most of them have drawn conclusions from selected geographical areas (8–10). There are only two studies with a national representative sample; the first one, from our own laboratory, using self-reported anthropometric indices to assess obesity rates in adolescents (11). The second one, published in 2007, reported data collected in 1990–1991 (ref. 12). Finally, although thinness is of major concern, particularly among young girls, relevant data for Greece is lacking.

Therefore, the aim of the present study was to examine the prevalence of underweight, overweight, and obesity, and to assess the trend during 1997–2007, in almost all 8- to 9-year-old children, in Greece.

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METHODS AND PROCEDURES

Participants

Population data are derived from 11 national school-based health surveys. Specifically, anthropometric data and information on age, gender, city and area were collected yearly, between 1 May and 15 June, from 1997 to 2007, with the exception of 2002, in almost all schools of primary education (roughly 85%); schools that did not participate were from borderland areas, with small numbers of children. Thus, from 1997 to 2007, a total of 651,582 children, aged 8–9 years (51% boys and 49% girls, over 95% of the total student population) participated in the present study (Table 1).

Ethical approval

Ethical approval for the health survey was graded by the Ethical Review Board of the Ministry of Education.

Measurements

Children's height and weight were measured in the morning using a standardized procedure. Weight was measured with electronic scales with a precision of 100 g. Standing height was determined to the nearest 0.5 cm with the child's weight being equally distributed on the two feet, head, back, and buttock on the vertical land of the height gauge. BMI was calculated as the ratio of body weight to the square of height (kg/m^2). BMI cutoff points were used by age and sex category (according to IOTF) for underweight, normal weight (13), overweight, and obese (14), as the most proper for epidemiologic studies (15).

International cutoff points for BMI for thinness grades 1, 2, and 3 by sex defined to pass through BMI of 16, 17, and 18.5 respectively, at age 18 (ref. 13). All anthropometric measurements were performed by two trained professionals in each class.

Data analysis

Descriptive statistics of BMI were expressed as means ± standard deviations. Prevalence of underweight, normal weight, overweight, and obesity was calculated as the ratio of those children belonging in the corresponding class, based on the proposed cutoff points for BMI by IOTF (13,14), and divided by the total number of children. Comparisons of the prevalence between genders were performed using the Pearson's χ^2 test. Tests for sex-specific trends in the aforementioned prevalence rates were performed using linear regression analysis (with lag 0). Serial dependency was evaluated using the partial autocorrelation function; no autocorrelation was observed for various lags tested. Results are presented as B coefficient ± s.e. Furthermore, joinpoint regression analysis was performed to test for differences in the slope of the point estimates between various time periods, using SEER*Stat version 3.3 software (Joinpoint Regression Program, April 2008). All other statistical analyses were performed using the SPSS version 14.0 software for Windows (SPSS, Chicago, IL). Statistical significance level from two-sided hypotheses was set at $P < 0.05$.

Table 1 Number of study subjects by gender and year

	Boys	Girls	
Year	*n* (%)	*n* (%)	Total (*n*)
1997	31,822 (51.3%)	30,173 (48.7%)	61,995
1998	31,802 (51%)	30,566 (49%)	62,368
1999	30,264 (51.3%)	28,714 (48.7%)	58,978
2000	33,501 (51.8%)	31,110 (48.5%)	64,611
2001	31,550 (51%)	30,224 (49%)	61,774
2003	33,660 (51.5%)	31,662 (48.5%)	65,332
2004	33,175 (50.8%)	32,109 (49.2%)	65,284
2005	35,234 (50.5%)	34,083 (49.5%)	69,817
2006	35,863 (51.1%)	34,333 (48.9%)	70,196
2007	36,396 (51.1%)	34,831 (48.9%)	71,227
Total	333,267 (51.2%)	317,805 (48.8%)	651,582

RESULTS

Prevalence of underweight, normal weight, overweight, and obesity are presented in Figures 1–4. Rates of overweight in boys increased from 19.6 ± 0.2% in 1997 to 26.5 ± 0.2% in 2007 ($P < 0.001$), whereas an increasing trend of 0.71 ± 0.1% ($P < 0.001$) per year in overweight was observed. For girls, an increase in overweight rates from 20.2 ± 0.2% to 26.7 ± 0.2% was evident between 1997 and 2007 ($P < 0.001$), with an annual increasing trend equal to 0.41 ± 0.05% ($P < 0.001$).

Figure 1 presents obesity prevalence throughout the studied period. It can be seen that an increasing trend exists in both genders; however, evidence for leveling off seems to hold in the years after 2004. Joinpoint regression analysis confirmed the previous observation that the turning point in the series of data occurred in 2004 for both boys ($P = 0.013$) and girls ($P = 0.050$). Thus, further analysis was performed, splitting the time series in two periods (1997–2004 and 2004–2007). Data analysis revealed an increase in obesity rates from 8.1 ± 0.2% in 1997 to 12.3 ± 0.2% in 2004 ($P < 0.001$) in boys, with an annual trend equal to 0.61 ± 0.04% ($P < 0.001$), and from 7.2 ± 0.2% in 1997 to 11.3 ± 0.2% in 2004 for girls ($P < 0.001$)

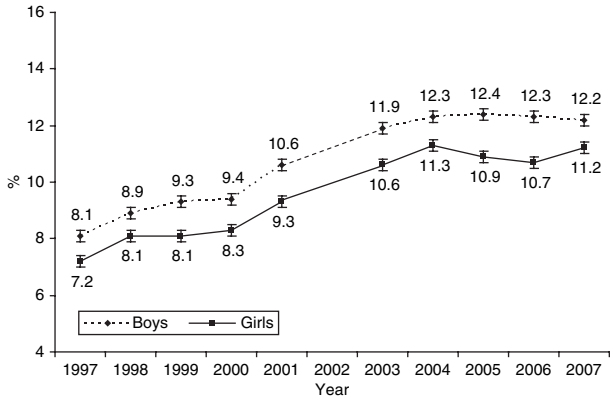

Figure 1 Prevalence (%) ± s.e. of obesity in 8- to 9-year-old children from 1997 to 2007.

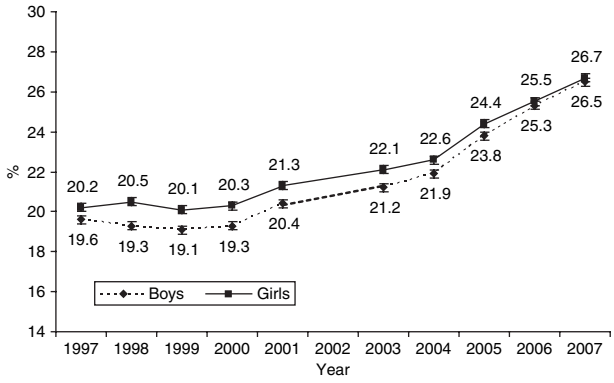

Figure 2 Prevalence (%) ± s.e. of overweight in 8- to 9-year-old children from 1997 to 2007.

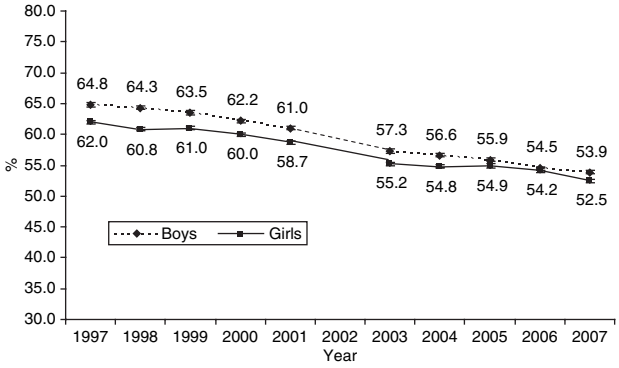

Figure 3 Prevalence (%) ± s.e. of normal weight in 8- to 9-year-old children from 1997 to 2007.

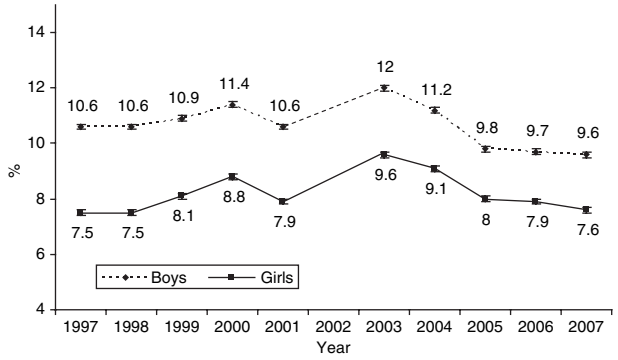

Figure 4 Prevalence (%) ± s.e. of underweight in 8- to 9-year-old children from 1997 to 2007.

with an annual trend equal to 0.57 ± 0.05% ($P < 0.001$). However, a leveling off in obesity rates was observed during 2004–2007 for both boys (−0.04 ± 0.03%, $P = 0.368$) and girls (0.05 ± 0.15%, $P = 0.766$). Further, gender-specific analysis showed that the prevalence of obesity was considerably higher in boys than in girls throughout the studied period ($P < 0.001$), whereas, the prevalence of overweight was higher in girls ($P < 0.001$).

Following recent IOTF cutoff points (13), prevalence of underweight during 1997–2007 are presented in **Figure 4**. The prevalence of underweight, as a total of three grades of thinness (i.e., grades 1, 2, and 3), decreased slightly for both sexes (**Figure 4**), and was lower in boys compared to girls ($P < 0.001$). Trend analysis revealed a nonsignificant decrease per −0.03 ± 0.08% per year for boys ($P = 0.71$) and per −0.1 ± 0.07% per year for girls ($P = 0.20$).

Regarding the prevalence of normal weight, it was decreased from 64.8 ± 0.3% in 1997 to 53.9 ± 0.3% in 2007 ($P < 0.001$) for boys and from 62 ± 0.3% to 52.5 ± 0.3% for girls ($P < 0.001$); the annual rate for boys was −1.19 ± 0.05% ($P < 0.001$) and for girls −0.95 ± 0.06% ($P < 0.001$). Moreover, the prevalence of normal weight was significantly lower in girls ($P < 0.001$) during the whole studied period. Finally, the ratio of obese-to-thin boys increased from roughly 1:8 in 1997 to 1:5 in 2007 and the ratio of obese-to-thin girls increased from roughly 1:9 in 1997 to 1:5 in 2007.

DISCUSSION

The findings from these consecutive epidemiologic, population-based surveys indicate that between 1997 and 2007, overweight and obesity in 8- to 9-year-old Greek boys and girls present significant increasing trends. It is noteworthy, albeit disturbing, to note that the percent of obese children increased by approximately four percentage points between 1997 and 2004, meaning that ~60,000 children became obese during this period. However, a leveling off in obesity rates was observed for the past 4 years of the study (2004–2007) for both boys and girls. Apparently, we will need to wait for a few more years before we can say that obesity rates in children have become stable; nevertheless, the observed plateau in the prevalence of obesity in 8- to 9-year-old children constitutes an interesting and optimistic finding.

Our study has several strengths. It was performed in this age–group for physiological and practical reasons. Before the age of 6 years, most children's BMI values run across BMI ranges, whereas toward the age of 6, the adiposity rebound usually occurs, following the minimum of the BMI curve (16). Furthermore, the predictability of adulthood overweight from childhood BMI values is better after the age of 6 years (17). For example, a recent report from the Newcastle Thousand Families Study (18) found that childhood (age 9 years) BMI was strongly associated with adult (age 50 years) BMI. Moreover, the age of 8–9 years is probably an advantageous period to apply effective obesity prevention strategies. At adolescence, physiological (pubertal stage) and behavioral (established dietary habits, eating disorders) factors may hinder prevention efforts. A second advantage of the presented data is that they are derived using the same standardized procedure of measurements and are based on almost all the child population of Greece. Moreover, the use of the IOTF cutoff points for BMI classification for underweight, normal weight (13), overweight, and obese (14) are the most proper for large epidemiological studies (15) and allow for direct comparisons of our results with those from other countries. Finally, primary education is compulsory in Greece, and therefore, we were able to study almost all 8- to 9-year-old children. The latter overcomes the methodological flaws of previous studies performed in Greece that were heterogeneous in terms of design, quality, target population, theoretical underpinning, and outcome measures, making it impossible to compare study findings with the data from other similar projects.

The presented results are in agreement with some (9,10) but not all (8,11,12) studies that have assessed overweight and obesity rates in 8- to 9-year-old Greek children. Specifically, Georgiadis and Nassis (12) reported obesity rates of 6.7% for girls and 5.9% for boys (data collected in 1990–1991). The fact that the present study began 6 years later (in 1997), could probably explain the higher obesity rates reported in our study compared with the study of Georgiadis and Nassis. Furthermore, our results differ from those of Krassas *et al.*, in 2001 (8), who reported prevalence of obesity was 5.6% among 6- to 10-year-old children. This discrepancy might be attributed, at least in part, to the fact that the data from the aforementioned survey

are based on a relatively small sample from only one Greek town. On the other hand, we are in line with the recent studies of Papadimitriou *et al.*, in 2006 (9), and Tokmakidis *et al.*, in 2006 (10), from selected regions of Greece, who have presented similar rates for overweight and obesity.

Our findings support the notion that childhood obesity rates in Greece are among the highest not only in Europe (19–32), but worldwide (33–35) (**Table 2**). Most of these studies (19–32) have used the IOTF cutoff points and, therefore, their data are directly comparable to ours. On the other hand, the study from Canada (34) has used national references, whereas the studies from the United States (33) and Australia (35) have used the Centers for Disease Control and Prevention references and not the IOTF as we did. These two references (i.e., Centers for Disease Control and Prevention and IOTF) seem to produce similar estimates of overall overweight prevalence but different estimates for obesity in this age–group (36).

A finding that deserves further attention is that although obesity rates were increasing steadily between 1997 and 2004, they remained stable thereafter (2004–2007). In agreement with the latter observation are results of recent surveys from the United States (33), Denmark (26), Germany (28), Sweden (31), Italy (37), and France (32). Specifically, Matthiessen *et al.*, 2008 (26), and Kromeyer-Hauschild and Zellner, 2007 (28), did not observe differences in the prevalence of obesity, between 1995 and 2001, among 7- to 14-year-old students from Denmark and Germany, respectively. In addition, Ogden *et al.*, 2008 (33), did not show a significant trend over time for the period 1999–2006 among 6- to 11-year-old children in BMI for age at or above the 95th percentile, whereas for the same time period, Lioret *et al.*, 2009 (32), report that the prevalence of overweight (including obesity) is currently stabilizing among French children aged 3–14 years. Finally, Sundblom *et al.*, 2008 (31), in their study among 10-year-old children from Sweden (1999–2003), suggested a leveling off in the prevalence of overweight and obesity.

The reasons for this apparent plateau observed in the prevalence of obesity among children from an ever-growing number of countries remain unclear. However, it could be hypothesized that obesity rates have reached a race and / or country specific

Table 2 Prevalence of obesity in selected countries

Study	Country, year	Sample	Obesity (%)
Kromeyer-Hauschild and Zellner (28)	Germany, 2007	1,918 children aged 7–14 years	1.8 (boys) 0.9 (girls)[a]
Matthiessen *et al.* (26)	Denmark, 2008	1,026 children aged 4–18 years	2.4 (total)[a]
van den Hurk *et al.* (24)	Holland, 2007	90,071 children aged 4–16 years	2.6 (boys) 3.3 (girls)[a]
Sundblom *et al.* (31)	Sweden, 2008	2,183 children aged 10 years	3.8 (boys) 2.8 (girls)[a]
Malecka-Tendera *et al.* (25)	Poland, 2005	2,916 children aged 7–9 years	3.6 (boys) 3.7 (girls)[a]
Rolland-Cachera *et al.* (20)	France, 2002	1,582 children aged 7–9 years	3.8 (total)[a]
Zimmermann *et al.* (22)	Switzerland, 2006	2,431 children aged 6–12 years	3.9 (boys) 3.8 (girls)[a]
Serra-Majem *et al.* (19)	Spain, 2006	990 children aged 6–13 years	4.7–10.4 (total)[a]
Stamatakis *et al.* (30)	England, 2005	28,601 children aged 5–10 years	5.2 (boys) 7.1 (girls)[a]
Celi *et al.* (29)	Italy, 2003	44,231 children aged 3–17 years	6.7 (boys) 6.5 (girls)[a]
Franklin *et al.* (35)	Australia, 2006	2,813 children aged 9–13 years	9.6 (boys) 7.0 (girls)[a]
Present study	Greece, 2007	71,227 children aged 8–9 years	12.2 (boys) 11.2 (girls)[a]
Tremblay and Willms (34)	Canada, 2003	8,539 children aged 4–12 years	13.5 (boys) 11.8 (girls)[b]
Ogden *et al.* (33)	United States, 2008	2,095 children aged 6–11 years	18 (boys) 15.8 (girls)[b]

[a]Classification of children as obese was made according to the cutoff points adopted by the International Obesity Task Force. [b]Classification of children as obese was made according to the cutoff points adopted by the US Centers for Disease Control and Prevention.

Table 3 Prevalence and trends from 1997 until 2007 of underweight (three grades) in 8- to 9-year-old Greek children

		Year										*P* for
Underweight		1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	trend
1st Grade	Boys % (s.e.)	5.6 (0.1)	5.9 (0.2)	5.9 (0.1)	6.2 (0.1)	5.7 (0.1)	6.9 (0.1)	6.8 (0.1)	6.0 (0.1)	5.9 (0.1)	5.5 (0.1)	0.63
	Girls % (s.e.)	7.4 (0.2)	8.0 (0.2)	7.4 (0.2)	7.5 (0.1)	6.8 (0.1)	8.0 (0.1)	7.8 (0.1)	6.8 (0.1)	6.7 (0.1)	6.7 (0.1)	0.13
2nd Grade	Boys % (s.e.)	1.4 (0.0)	1.1 (0.0)	1.6 (0.0)	1.8 (0.0)	1.4 (0.0)	1.8 (0.0)	1.5 (0.0)	1.2 (0.0)	1.3 (0.0)	1.3 (0.0)	0.71
	Girls % (s.e.)	2.2 (0.0)	1.7 (0.0)	2.5 (0.0)	2.5 (0.0)	2.3 (0.0)	2.5 (0.0)	2.2 (0.0)	1.8 (0.0)	1.9 (0.0)	1.8 (0.0)	0.29
3rd Grade	Boys % (s.e.)	0.5 (0.0)	0.5 (0.0)	0.6 (0.0)	0.8 (0.0)	0.8 (0.0)	0.9 (0.0)	0.8 (0.0)	0.8 (0.0)	0.7 (0.0)	0.8 (0.0)	0.82
	Girls % (s.e.)	1.0 (0.0)	0.9 (0.0)	1.0 (0.0)	1.4 (0.0)	1.5 (0.0)	1.5 (0.0)	1.2 (0.0)	1.2 (0.0)	1.1 (0.0)	1.1 (0.0)	0.98

P for trend derived from linear regression analysis. Classification of children as underweight was made according to the cutoff points adopted by the International Obesity Task Force (13).

ceiling. In other words, the percent of children "destined" to be obese are now obese and, therefore, obesity rates will not increase any further. Another potential explanation is that the cutoffs used for defining BMI categories need re-evaluation under the light of current metabolic and anthropometric data. Perhaps the distribution of BMI among children has shifted against the mean values of previous surveys. Finally, from the public health care perspective, an encouraging explanation might be that this phenomenon is the result of the continuous efforts of scientists and governments toward prevention and treatment of childhood obesity. Nevertheless, it is probably too early to say with certainty that obesity rates have leveled off, let alone to draw reliable conclusions for its cause.

The present study reports a dramatic increase (by 52%) in the prevalence of obesity in Greece in the past decade among 8- to 9-year-old children of both genders. As childhood obesity has evolved into a worldwide epidemic, it is essential that countries continuously monitor weight status because many obese children have become obese adults (5) and the established obesity in adults is difficult to treat. Studies that monitor annual changes in overweight/obese provide a useful tool for prevention by contributing to the development of an effective public policy response (2). Necessity for prevention is supported by the fact that long-term outcome data for successful treatment approaches are limited (38).

Regarding underweight, there is very little information in European children and no data from Greece. The prevalence of underweight in the present study is similar to that reported from other European countries. Specifically, Boddy *et al.*, 2008 (39), Martinez-Vizcaino *et al.*, 2008 (40), and Lazzeri *et al.*, 2008 (37) have reported overall prevalence of underweight ranging from 6.2 to 9.5% and found significantly higher prevalence in girls, a finding similar to ours (**Figure 4**, **Table 3**).

Limitations of the present study include some methodological issues, and the fact that potential confounding factors, such as physical activity status and nutrition habits, have not been evaluated. Specifically, although a standard protocol was used to measure children's height and weight throughout these 11 years, the large number of professionals who have participated as evaluators, may have introduced inter-observer measurement error. Additionally, because of the large sample size, statistical significance can easily be achieved. Finally, prevalence of overweight and obesity was evaluated in a narrow age–group (i.e., children aged 8–9 years), and therefore, one should exercise caution when extrapolating these findings to other age–groups.

Despite the aforementioned limitations, this is the first study that reports on the long-term and most recent underweight, overweight, and obesity prevalence trends in Greek children. Results revealed that obesity and overweight rates among 8- to 9-year-old children of both sexes increased at alarming rates during the past decade. An encouraging leveling off in obesity rates was observed for the past 4 years. Boys and girls present similar trends in relation to normal weight, overweight, and obesity. These trends suggest changes in environmental factors, such as nutrition and physical activity that need to be further considered. Serious and urgent actions need to be taken from public health policy makers affecting both social and market environments in order not only to prevent a further increase in overweight and obesity rates, but, more importantly, to treat obesity and/or the obesity-associated comorbidities.

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DISCLOSURE

The authors declared no conflict of interest.

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