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Prevalence of Gestational Diabetes Mellitus in Puerto Rico: A Study from 2016 to 2021

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Abstract

Background: Gestational diabetes mellitus (GDM) is a temporary form of insulin resistance during pregnancy and is linked to adverse outcomes for both mothers and offspring. Maternal risks include an increased prevalence of preeclampsia, cesarean delivery, and the development of type 2 diabetes within five to ten years post-delivery. For offspring, exposure to elevated maternal glucose levels is associated with macrosomia. A significant challenge in evaluating the prevalence of GDM in Puerto Rico is the lack of recent research quantifying this condition in pregnant women living in Puerto Rico. **Objective:** This study aimed to estimate the prevalence of Gestational Diabetes Mellitus from 2016 to 2021 by analyzing data collected by Puerto Rico's Department of Health. **Methods:** We obtained publicly accessible data from the Division of Children, Mothers, and Adolescents from Puerto Rico's Department of Health to estimate the prevalence of GDM across the island. Additionally, we correlated the prevalence with socioeconomic, educational, and demographic variables using beta regression models to assess their significance. **Results:** The prevalence of GDM ranged from 3.2% to 4.5% for the six years studied, with an average prevalence of 3.68%. Regression analysis revealed a significant positive relationship between maternal age and educational level. Higher educational attainment was associated with a reduced risk of GDM, while increasing maternal age was linked to a higher prevalence of the condition. **Conclusion:** This statistical analysis provides evidence of a steady increase in the prevalence of GDM in Puerto Rico from 2016 to 2021, highlighting the importance of ongoing surveillance and specific interventions to mitigate risk factors.

Keywords

Gestational Diabetes Mellitus, Diabetes, Glucose Intolerance, Pregnancy in

Diabetics, Hispanic Women, Puerto Rico

1. Introduction

Gestational diabetes mellitus (GDM), or gestational diabetes, is a temporary form of insulin resistance that occurs during pregnancy [1]. It is the most common metabolic disorder in pregnant women and is associated with adverse outcomes for both mothers and their babies [2]. Typically, a healthy pregnancy involves physiological changes that help the mother meet the increasing demands of the fetus throughout its development. One important metabolic adaptation is the shift in insulin sensitivity, which varies throughout pregnancy [1] [3]. During the initial stages of pregnancy, insulin sensitivity increases, allowing glucose to be stored in adipose tissue in preparation for the energy demands of later pregnancy. However, in some pregnancies, this adjustment is impaired, causing disruptions like GDM [1]. GDM affects 7% of all pregnancies and can result in serious long-term complications [4]. For mothers, risks include a higher prevalence of pre-eclampsia, cesarean delivery, and 50% of developing type 2 diabetes (T2DM) within five to ten years postpartum [4]. For offspring, exposure to elevated maternal glucose levels is linked to macrosomia [5] [6], shoulder dystocia [7], neonatal hypoglycemia [8] [9], intrauterine fetal death [10] [11], impaired glucose tolerance [12], and obesity in childhood [4].

Unfortunately, there are no widely accepted treatment or prevention strategies for GDM aside from lifestyle interventions and, occasionally, insulin therapy [13]. Research quantifying the prevalence of GDM in Puerto Rico is limited. We encountered only one recent study involving 142 women from the Maternal Infant Clinic at the University of Puerto Rico [14]. This study evaluated the maternal and neonatal outcomes after administering oral hypoglycemic agents. The selection criteria were not based on demographic data but on women who had been administered metformin, sulfonylureas, or insulin to achieve glycemic control. Of the sample, 90% had a confirmed diagnosis of GDM.

Early detection of GDM is crucial, as it can help mothers seek better antepartum care through dietary adjustments and exercise. Several maternal factors, such as age, educational level, and socioeconomic status, are known to play an essential role in the diagnosis and development of this condition. As part of the social determinants of health, they contribute to the growth of health disparities [15]. Advanced maternal age increases the risk of various pregnancy complications, including hypertensive disorders, postpartum hemorrhage, and preterm birth [16]. GDM prevalence is also higher among women with lower levels of education, as this influences income, occupational status [17], and socioeconomic standing. The combined effect of lower education and advanced maternal age is more significant than their individual impacts, significantly increasing the likelihood of GDM, especially in middle-aged women [18].

Over the past decade, multiple studies have surfaced with the intent to study the manifestation of gestational diabetes across different racial and ethnic groups, including Hispanic [19] [20], Asian [19] [20], non-Hispanic White [19] [20], and non-Hispanic Black [19] [20]. Cultural backgrounds and traditions influence lifestyle patterns and behaviors, leading to variations in gestational diabetes rates among ethnic groups [21]. Given the lack of a comprehensive profile of women affected by GDM living in Puerto Rico, our research aims to address this gap.

The Behavioral Risk Factor Surveillance System report from 2017 indicated a 17.2% prevalence of diabetes mellitus in Puerto Rico, significantly higher than the 10.5% reported for all U.S. states and the District of Columbia [22]. Women of low socioeconomic status were found to be at a higher risk for this endocrinological condition [22]. With the ongoing trend of circular migration between Puerto Rico and the U.S., it is imperative to study GDM in women currently living in Puerto Rico, as the mainland diaspora may present a biased subset due to varying socioeconomic factors.

The objective of this study was to estimate the prevalence of gestational diabetes mellitus in Puerto Rico from 2016 to 2021.

2. Methods

2.1. Materials and Data Procurement

This study's data was obtained from Puerto Rico's Department of Health, specifically the Division of Children, Mothers and Adolescents. Upon issuing an IRB approval (IRB approval number: EMSJBIRB-17-2023), we obtained publicly accessible data containing 4796 GDM-positive cases and 132,686 live births in Puerto Rico from the year 2016 to 2021. The information used in this study was from a database of the Puerto Rico Department of Health that was collected from the Demographic Registry, specifically from the birth certificate. The birth certificate is divided into two parts. The first part includes information regarding education level, health insurance, marital status, and other details that the mothers must complete. The second part consists of prenatal conditions and any illnesses the mother may have had, which is completed by the doctor. This part includes a question on whether the mother had diabetes during pregnancy. This information is provided yearly to the Department of Health by the Demographic Registry. The variables included in the analysis were: GDM-Positive and GDM-Negative women for each of the 78 municipalities across the six years of this study; age group of the mothers, scholarly level of the mothers, and total number of births each year.

We appended a database procured from Puerto Rico's Health Department of socio-economic variables, from Oficina del Contralor: Estadísticas Municipales [23], which included income per capita and poverty percentage for each municipality. The statistics presented on this webpage only included the latest data published, which was 2020. Alongside these statistics, we obtained the latitude and longitude coordinates for the center of each municipality to build a geolocated

heatmap.

2.2. Study Sample

This is a convenience sample study since we use a non-randomized sample drawn from a population readily accessible to our research group through the Department of Health. The maternal data used to calculate the prevalence of GDM included participants who had received a positive diagnosis. Women with a negative diagnosis of GDM were included in the overall annual birth data. For inclusion in the study, participants had to be 21 years or older and live in Puerto Rico at the time of delivery, regardless of their nationality. The cohort included both nulliparous and multiparous women, taking into account their pregnancy history of GDM. Exclusion criteria included women with a prior diagnosis of diabetes mellitus (Type 1 or Type 2) or hypoglycemia before the study began.

2.3. Statistical Analysis

We conducted the statistical analysis using beta regression, a generalized linear model suited for modeling proportions (values bounded between 0 and 1) that do not follow normal distribution [24]. Since linear models are inappropriate for such data, beta regression was chosen. We constructed a model to study the relationship between the demographic, educational, and socio-economic variables, including income per capita, poverty percentage for each municipality, high school education or beyond, and average prevalence by age group. A subset containing three age groups was also correlated with a variable of interest, *y*, representing the average prevalence by age group.

The educational variable corresponding to "high school education or less" was excluded from these models due to its small sample size, which had minimal impact. The model was generated with the *betareg* package in R-studio.

3. Results

3.1. Socioeconomic and Demographics

This study is retrospective and descriptive in nature. To measure the effect of the previously mentioned variables, we conducted three distinct beta regression analyses utilizing the data to evaluate whether there is a significant correlation between the socioeconomic and demographic variables and GDM prevalence (**Table 1**). The socioeconomic data presented include the mother's municipality of residence, her educational level, and GDM prevalence in each municipality. The data was arranged by geographical zones, highlighting the municipalities with the lowest and highest prevalence in each zone of Puerto Rico. Prevalence was calculated for each municipality as the ratio of the total number of GDM-positive diagnoses to the total number of births in that municipality.

3.2. Gestational Diabetes Mellitus Prevalence

The prevalence of gestational diabetes ranged from 3.2% to 4.5% across the six

years included in this study, with a mean of 3.68%. These results present the yearly incidence of gestational diabetes in Puerto Rico, showing the number of GDM-positive cases recorded each year, along with the overall birth rate (Table 2). The birth rate includes GDM-positive and GDM-negative cases.

Table 1. Data analyzed for GDM present in Puerto Rican women during 2016-2021, organized by municipalities with the lowest to highest distribution of prevalence percentage for each geographical zone, respectively (H.S. High School).

Municipality		Education		Socioeconomic[b]	
	Prevalence[a]	Less than H.S. education	H.S. education or beyond	Income per capita of municipality	% of poverty by municipality
North of Puerto Rico					
Barceloneta	0.001	0.000	0.955	9847	48.6
Carolina	0.041	0.242	0.940	16,846	30.9
South of Puerto Rico					
Guayama	0.230	0.556	0.883	10,387	50.2
Peñuelas	0.065	0.231	0.911	9480	57.4
East of Puerto Rico					
Naguabo	0.008	0.571	0.906	9283	47.4
Luquillo	0.061	0.182	0.925	11,123	42.6
Center of Puerto Rico					
Cidra	0.016	0.100	0.902	10,980	44.7
Jayuya	0.063	0.400	0.906	7308	61.0
West of Puerto Rico					
San Sebastián	0.033	0.214	0.897	9498	53.5
Yauco	0.064	0.125	0.947	8404	49.0

a. Calculated by the number of women diagnosed with GDM over the number of women in that municipality across all years. b. Socioeconomic variables were obtained from *Oficina del Contralor: Estadísticas Municipales* (https://www.ocpr.gov.pr/informacion-y-prensa/estadisticas-municipales/).

Table 2. Yearly incidence of GDM from 2016 to 2021, total births and prevalence for each year.

Years	GDM-positive cases	Births recorded per year[a]	Yearly prevalence
2016	893	28,266	3.16
2017	722	24,328	3.00
2018	803	21,422	3.75
2019	730	20,344	3.60
2020	789	19,018	4.15
2021	859	19,308	4.45
Total GDM-Positive cases studied: 4796		**Total Births:** 132,686	

a. The variable of annual births includes GDM-Negative cases.

As presented in Table 1, we found a higher prevalence in some of the south, western, and eastern municipalities of Puerto Rico, like Yauco, Peñuelas, and Luquillo, respectively. The prevalence across all of the 78 municipalities ranged from 19 to 148 cases; a heatmap containing said distribution is shown in Figure 1. The heatmap was constructed with *Tableau.* The municipality with the smallest distribution of prevalence was Naguabo (0.008), and the municipality with the biggest distribution was Peñuelas (0.065). In some municipalities, the sample size for annual births and GDM-Positive diagnoses is small, as reflected in the significant decline in annual birth rates shown in Table 2.

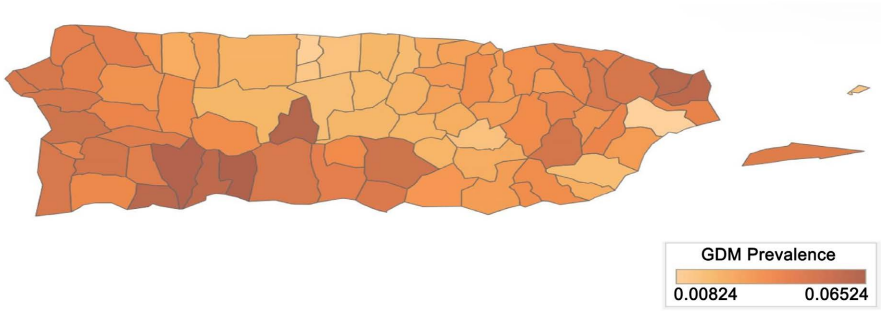

Figure 1. Heatmap of mean prevalence of GDM distributed across municipalities for 2016-2021.

We hypothesized that the economic variables, the mother's municipality of residence, and age-related variables would significantly impact the diagnosis of GDM within the sample. Our results indicate that GDM prevalence varies significantly across the age groups included in our sample. The 20 - 34 age group had the highest incidence, followed by women aged 35 and older. Notably, the prevalence in the 20 - 34 age group was significantly higher (Figure 2).

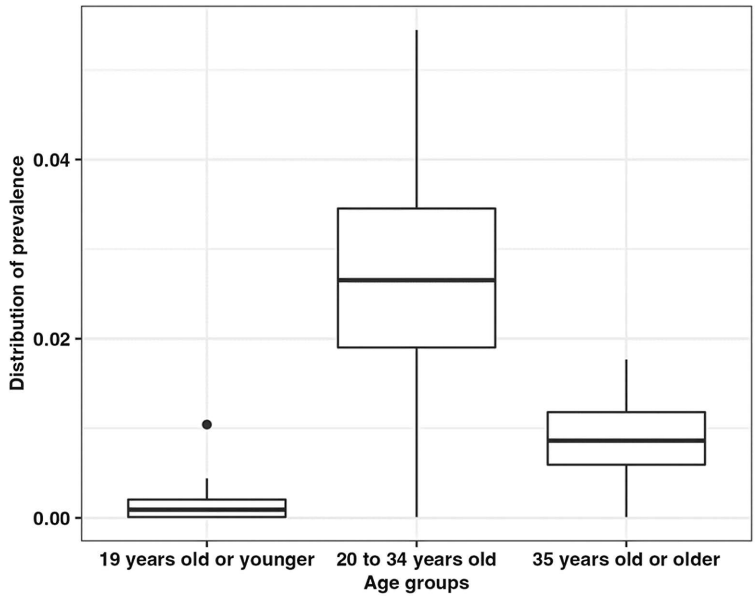

Figure 2. Prevalence of GDM through three different age groups.

3.3. The Effect of Age and Education

Table 3 shows a detailed breakdown of the results from the *betareg* analysis. Initially, we hypothesized that the economic variables of the mother's municipality of residence and age-related variables would have a significant impact on the diagnosis of GDM in the sample size. The model demonstrated that age groups of 20 - 34 years old and 35 years or older were the only variables that held a significant correlation.

Table 3. Beta regression analysis.

	Variable	Coefficient	Std. Error	p-value
Socioeconomic	Income per capita for each municipality	<0.0002	<0.0001	0.321
	Poverty percentage for each municipality	<0.01	0.009	0.175
Education	High School education or beyond	−2.417	1.243	0.052
Age	20 - 34 years old	−2.524	0.121	<0.001
	35 years old or older	−1.067	0.081	<0.001

The beta regression model conducted for the age group variables demonstrated no significant correlation in the ages 19 years or younger. The highest probability was observed for the 20 - 34 years old (beta regression coef. = −2.524, $p < 0.001$) and the 35 years or older (beta regression coef. = −1.067, $p < 0.001$). The prevalence of GDM was found to correlate with both age and education levels at the municipality level. Younger mothers (19 and under) and older mothers (35 and above) had a significantly lower risk of GDM compared to those in the intermediate age group (Figure 3).

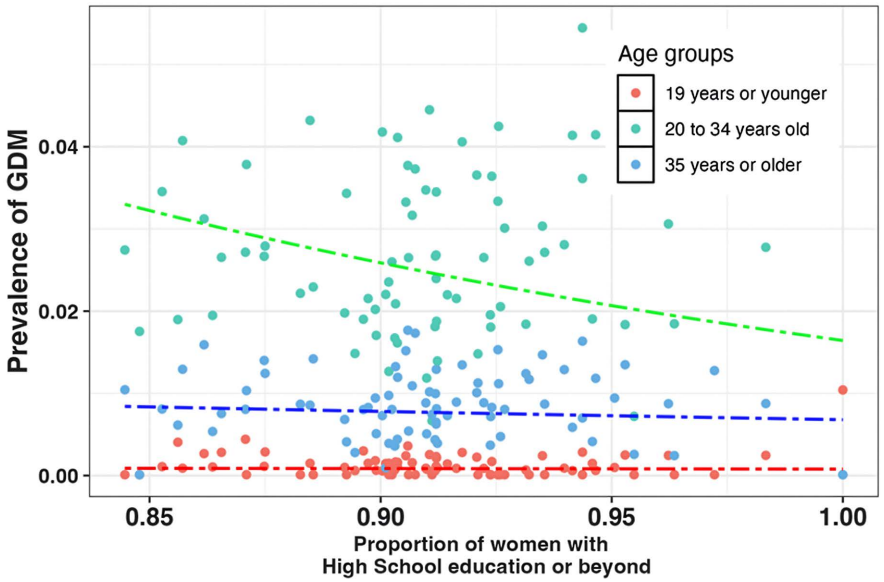

Figure 3. Decrease of GDM prevalence amongst age groups as proportion of education level increases.

No differences were observed in the prevalence of GDM among mothers with a high school education when analyzed at the municipality level for those aged 19 years or older. However, a significant change in prevalence was noted for the age group of 20 - 34 years old (beta regression coef. = −2.524, $p < 0.001$; **Figure 3**), and 35 years or older (beta regression coef. = −1.067, $p < 0.001$), where the proportion of mothers with high school education or beyond at the municipality level was lower. The probability of 35 years old or older who are GDM-Positive is higher than the probability for the 19-year-old or younger group. Both groups do not influence the correlation between high school and higher education with gestational diabetes. Additionally, we observed that in the 20 - 34 age group, the prevalence of GDM decreased as the proportion of women pursuing secondary education or higher education increased.

4. Discussion

Gestational diabetes mellitus represents the most prevalent metabolic disturbance during pregnancy and serves as a precursor to long-term cardiometabolic diseases [25]. The evidence of a consistent increase in GDM in Puerto Rico from 2016 to 2021 appears to be present, ranging from 3.2% to 4.5%. This steady rise appears unrelated to changes in the birth demographics over the years, which suggests that GDM is likely independent of variations in the population structure. Moreover, we observed a slight increase in the prevalence of GDM during the COVID-19 pandemic years (2020-2021), a trend consistent with prior studies [26]-[29]. This surge may be attributed to pandemic-related lifestyle shifts such as remote work, homeschooling, gym closures, periodic lockdowns, and fear of COVID-19 exposure, all of which potentially contributed to the rise in pre-pregnancy BMI and heightened anxiety levels [30]. Surveys conducted among pregnant women diagnosed with GDM during this period have reported increased sedentary behavior, reinforcing these findings. However, further research must assess how lifestyle and cultural factors, particularly within ethnically diverse populations, have contributed to these trends [31]. The potential efficacy of telehealth services in providing dietary and gynecological care, as opposed to the traditional gold-standard methods, remains uncertain, and additional studies are warranted in this area.

The age-related results are consistent with previously published data. We hypothesized that factors such as income per capita and the poverty rate within the mother's municipality of residence might have a significant bearing on GDM incidence. Given Puerto Rico's prolonged economic decline–triggered by the 2006 recession and further exacerbated by the devastation of Hurricane Maria in 2017–understanding the interplay between economic hardship and health outcomes became a critical focus of our research [32]. The increment in poverty across various municipalities has undoubtedly affected the quality of life for many pregnant women, limiting their access to basic necessities and healthcare. Despite this, the beta regression models corresponding to the socioeconomic variables of the municipality of residence did not present significant results.

However, we observed an elevated incidence of GDM in certain municipalities in Puerto Rico's western, southern, and metropolitan regions. These results were striking as the east and south municipalities are a key factor in Puerto Rico's agricultural sector [33]. We hypothesized that municipalities with greater involvement in agriculture might report lower GDM prevalence due to increased access to fresh, locally grown produce, a vital component of the local diet. Nevertheless, after Hurricane María and the COVID-19 pandemic, food insecurity has become an increasing reality for many island residents. The island's heavy reliance on imported food from the United States, compounded by damage to local agricultural infrastructure, may have contributed to the deterioration of dietary habits in these regions [32] [34]. These disruptions likely influenced the higher GDM rates seen in the southern and western municipalities, but more research is needed to link these nutritional shifts to GDM prevalence conclusively.

In the distribution of GDM across the age groups, 160 women in the sample were 19 years old or younger, and the prevalence was not considered significant. On the contrary, our sample contained 3417 20 to 34-year-old women, which reported the highest prevalence. A high-paced lifestyle, sedentary behavior, and a high-fat diet can cause an increase in the prevalence of GDM in 20- to 34-year-olds [35]. While trying to identify the relationship of this significant age group with the rest of the variables, we examined the effect that education had on this group through beta regression models. The results indicated that as the mother's level of education–whether secondary or higher–increased, the prevalence of GDM decreased. This inverse relationship, while paradoxical, may reflect the broader trend of more women pursuing higher educational status, which is often associated with better nutritional access, higher socio-economic status, healthcare access, and educational tools.

There are, of course, limitations to this study. The Puerto Rican Department of Health collects a limited set of demographic data on GDM, which constrains the depth of analysis and conclusions that can be drawn regarding this metabolic condition. The study for risk factors for GDM lacks certain key data points that were unavailable, which may impact the study's findings and conclusions. For example, specific socioeconomic indicators, genetic predisposition details, and granular lifestyle information, such as exact dietary intake or physical activity levels, were not accessible. This data would have allowed for a more comprehensive analysis of factors influencing GDM risk. Without this information, the study relies on broader demographic and self-reported data, which may not fully capture the unique combinations of risk factors among our population. Consequently, the absence of this data limits the investigators' ability to analyze the full range of risk influences, potentially affecting the generalizability of the findings. Moreover, in analyzing the data through beta regressions, possible confounders might have been introduced, particularly given the model's sensitivity when dealing with observations near zero. Also, while we analyzed socioeconomic variables such as income per capita and poverty levels, these data were limited to the year 2020, in contrast to other variables, which include a conglomerate of data spanning the full

six years of this study. Lastly, another limitation worth noting is the inclusion of the COVID-19 pandemic years (2020-2021), which may have contributed to the slight increase in GDM cases observed during that period. However, more research is needed to evaluate how lifestyle, cultural factors, and restrictions during the pandemic could have impacted GDM incidence in Puerto Rico.

In conclusion, GDM is a growing public health concern among women living in Puerto Rico. This study, while epidemiological in nature, hopes to catalyze deeper conversation about promoting healthier lifestyle changes, dietary modifications, and a reconsideration of certain cultural norms that may exacerbate the risk of GDM. Puerto Rico's cultural landscape includes several factors that may increase the predisposition to GDM among pregnant women. Traditional Puerto Rican cuisine, often rich in carbohydrates, sugars, and fats, can contribute to higher rates of obesity and diabetes, key risk factors for GDM. Additionally, economic challenges and limited access to fresh, healthy food options in certain areas may further impact dietary choices, increasing reliance on processed and fast foods. Physical activity levels may also be lower in specific communities due to lifestyle patterns or limited access to safe recreational spaces, which can contribute to weight gain and insulin resistance. Furthermore, there may be limited awareness or knowledge about GDM prevention and management within communities, partly due to linguistic and educational barriers. These factors, combined with the genetic predisposition found in Hispanic populations for diabetes, underscore the need for more studies that include these risk factors in our population and culturally tailored education programs to address GDM risks in Puerto Rico effectively. We hope that our findings aim to contribute to the broader efforts of the Puerto Rico Health Department, with the potential to guide the development of programs designed to help women achieve a healthy pregnancy. Establishing policies and intervention strategies in collaboration with local health organizations is essential to address GDM in Puerto Rico because it enables targeted, culturally relevant public health initiatives that directly respond to the unique needs and risk factors of the local population. Local organizations have insight into community-specific barriers to healthcare access, such as socioeconomic factors, dietary habits, and lifestyle trends, which are critical in managing and preventing gestational diabetes. Collaborating with these organizations allows for more effective outreach, especially in rural or underserved areas, through educational programs, expanded prenatal screenings, and accessible telehealth services. Moreover, policy support ensures that these initiatives receive sustained funding and guidance, promoting early detection, healthy lifestyle interventions, and postpartum follow-up that can improve maternal and infant health outcomes. Lastly, we strongly recommend and encourage that future studies investigate the role of socioeconomic status in GDM diagnosis, particularly to better understand how these variable shapes health outcomes across the island.

Conflicts of Interest

The authors declare that the research was conducted without any commercial or

financial relationship that could be construed as a potential conflict of interest.

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