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Evaluation of the Social and Economic Base in the Spatial Distribution of the Diabetes Prevalence: A Case Study of Zanjan City

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ABSTRACT

Background: As cities are the focus of health services and diseases, it is noteworthy that two-thirds of the global population affected by diabetes, totaling 415 million individuals, live in urban areas. Consequently, cities have become the main centers of health interventions aimed at reducing the growing curve of diabetes. The current study aims to investigate the effect of urban factors on the prevalence of diabetes, with a particular focus on the spatial and spatial differences in Zanjan City, with an applied developmental goal.
Methods: The current study employs a descriptive survey method. Geographic information systems (GIS) have been used to understand the spatial difference in the incidence of diabetes. For this purpose, after collecting information, a database was created in ArcCatalog, and spatial statistics tools in ArcMap.
Results: The analysis, supported by Movaren's index with a coefficient of 1.64 confirms the presence of special clusters in diabetes distribution within Zanjan City. Cold spots, indicating lower prevalence, are centered in the southern and southwestern regions, while higher incidence is observed in the northeastern and northwestern parts of the city, with a statistically significant confidence level of 99 %. The regression results also show a strong and positive relationship between certain occupational sectors, such as art and entertainment (coefficient of 2.5), transportation (coefficient of 3.5), and the food industry (coefficient of 2.01) with this disease. In terms of the spatial distribution of diabetes, there is a significant relationship. A strong and positive correlation at the 99 % confidence level can be seen in Darmangah, Shahrak Shahada, and Qeysarieh.
Conclusion: The findings of the present study underscore the existence of a cluster pattern in the occurrence of diabetes within Zanjan City.

1. Introduction

Cities are at the forefront in addressing the challenge of diabetes, as they accommodate a significant portion of the global population, with more than two-thirds of individuals and over 8 % of adults affected by this condition [1]. Notably, the prevalence of diabetes has witnessed a substantial increase of over 28 million people since 2014 [1]. Consequently, the growing trend of diabetes has garnered increased attention over time [2]. Diabetes, which is caused by the resistance of body cells to insulin [3], is the seventh leading cause of disability and the fourth leading cause of mortality in high-income countries. Besides the direct costs of health care treatment, substantial indirect costs manifest in terms of reduced productivity among individuals on vacation or in the workplace, alongside a decline in labor force participation in society [4]. Biological risk factors as main contributors and behavioral and environmental factors as indirect risk factors are effective in the occurrence of diabetes [5]. Research has shown that in addition to

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individual factors such as physical inactivity, disordered eating behaviors, age, ethnicity, overweight, and genetic predisposition [6, 3], physical, social, and cultural factors significantly shape individual behaviors and contribute to the development of diabetes [1]. Local environments shape individual behaviors and are effective in the occurrence of diabetes by either facilitating or restricting individual choices such as dietary habits and physical activity patterns [7]. These environments not only influence an individual's health but also have a direct relationship with the management of high-risk health behaviors [8-10]. The hypothesis that diabetes is caused by the interaction between genetic factors and lifestyle and is influenced by the surrounding environment was first proposed 50 years ago. This paradigm assigns personalized responsibility to lifestyle risks, behavioral patterns, nutrition, and ensuring health consequences, which originates from environmental and social factors [11]. However, until recent years, genetic factors have received more emphasis than behavioral and environmental factors [1, 7]. Soholt, a Danish architect, believes that urban planning interventions are necessary to address this disease effectively [1] In order to comprehend the spatial correlation between the built environment and health, it becomes crucial to gain a thorough understanding of the local environment. This understanding serves as a foundation for formulating more effective policies aimed at creating an artificial environment conducive to mitigating chronic diseases [7]. This research is the first study that quantifies the incidence of diabetes in Zanjan City using geographical approaches. Therefore, the current study seeks to investigate the epidemiology of the region in Zanjan, analyze the relationship between exposure to the built environment, and gain a deeper understanding of patterns related to high-risk populations and their environment.

1.1 Theoretical Basis (Theoretical Framework and Literature Review)

Contemporary cities face significant health challenges, with chronic diseases, particularly diabetes, replacing the killers that historically posed a threat to human life. In most countries, the prevalence of diabetes has increased simultaneously with rapid cultural and social changes, which is not unrelated to the increase in urbanization [5]. Two important social phenomena, namely population aging and increasing rates of overweight individuals, have strongly affected the incidence of diabetes; both of which are directly related to urbanization. This shows that although genetic factors are effective in the occurrence of diseases, social, cultural, and physical factors also play a significant role in people's health. These factors affect an individual's lifestyle, diabetes risk, treatment outcomes, and care. Over time, the relationship between the mentioned factors and diabetes prevalence is becoming clearer. While social factors are well understood, the role of culture as a mediator of health is not as extensively explored. Social factors are a wide set of forces and systems that shape daily life, including the distribution of financial resources, power, and access to resources at global, national, and local levels. Health inequalities arise from disparities in finances, geographical location, time factors, and resource accessibility [12]. Cultural factors, as external determinants, deal with environmental, geographical, political, and economic nature [13]. Cultural determinants of health are factors that determine how contracts, understandings, and common functions affect health. These factors form the foundation from which social factors such as traditions and norms, and a common understanding of health, illness, and body size emerge [14]. Social and cultural determinants indicate the vulnerability of people to diabetes. Vulnerability is a range of biomedical, social, and cultural factors. While biomedical agents are well known, there is little information regarding the social, cultural, and physical factors that are significantly effective in the vulnerability of diabetes. Knowing these factors, alongside biomedical factors, provides a comprehensive understanding of diabetes vulnerability. The vulnerability rate is determined by a combination of social, cultural, and biomedical indicators, with the most vulnerable individuals experiencing all these determinants, while the least vulnerable individuals do not encounter any social and cultural determinants even in the face of biological factors. Social factors of health are related to the conditions of birth, growth, life, occupation, and old age, which in turn affect health outcomes [11]. Being aware of the dynamics of urban environments and identifying the potential health benefits of cities is crucial for addressing urban diabetes. Complex urban environments affect the health of citizens through a set of physical, social, cultural, and economic factors [15]. They are often referred to as major centers of the diabetes epidemic. Inactive urban transportation reduced physical activity, and specific occupational groups, dietary changes, and increased calorie intake contribute to the emergence of high-risk cities for diabetes with cultural and social mediators [1]. Today, more than half of the world's population is faced with diabetes [16]. This has caused not only the cities to be known as the most important centers for dealing with diabetes; but also, it has caused a better understanding of urban diabetes and its requirements to be the main topic of dealing with the growth of diabetes in the world. The relationship between urbanization and health is multifaceted. On the one hand, the combination of economy and mass demand has reduced the cost of health services and infrastructure, and on the other hand, the urban lifestyle, the increase in health inequalities in urban areas [17], the significant decrease in mental and physical health due to the increase in stressful factors such as high crime rates, psycho-social violence and high population density in the lower neighborhoods of the city have been effective in the health of citizens; and exposed them to dangerous and harmful health factors [18]. Studies have shown that urban slums have an upward trend in the incidence of diabetes, and citizens with lower education levels are associated with a higher prevalence of diabetes risk factors. Additionally, individuals with a Western background tend to have lower diabetes risk behaviors compared to those with a non-western background [19]. Changes in eating habits, physical activity, work patterns, smoking, alcohol consumption, leisure time, and travel patterns, all affect health [1]. In some cities, diabetes is affected by demographic factors and accessibility, and it has a cluster and spatial state. Health-promoting features, such as the availability of fruit and vegetable stores, have helped mitigate the increase of diabetes in urban areas [5]. In early 2014, the Cities Changing Diabetes program was implemented on a global scale to support urgent actions on diabetes with the aim of mapping challenges, and prospects and sharing solutions to control the prevalence of diabetes. This program aims to make cities healthy places to live, by reducing the risk of diabetes in five cities: Mexico City, Copenhagen, Houston, Tianjin, and Shanghai. The macrostructure of this program is to monitor the state of diabetes in cities, share the links between the urban form and structure of diabetes, and intervene in local designs and the urban body in order to reduce the incidence of this disease [1]. In Iran, many studies have been done in the field of medical geography. Although the number of these studies is limited. Some of these studies are mentioned below. Medical geography studies on the relationship between heavy metals and cancers [20], malaria disease [21], the relationship between lung cancer and agricultural fertilizers [22], mortality zoning in Khuzestan province [23], the zoning of Malt fever [24], the spatial distribution of anemia [25], the spatial analysis of women's diseases [26] can be counted among these studies. Rezaei *et al.* (2018) used different pattern recognition methods to diagnose the incidence of thyroid disease and did not pay attention only to medical and genetic factors. In a study [27], Moghadam *et al.* (2019) investigated the relationship between overweight and travel patterns in Zanjan City and then obtained the final map of areas prone to overweight from the perspective of travel patterns. The results of this article have shown that less than 3 % of the city's area is not prone to overweight and more than 69.90 % of the city's area is very favorable for overweight in Zanjan City [28]. Rahnama and Bazaregan (2019) conducted a study that underscored the significance of comprehending the variations in the geographic distribution of infectious diseases. Their research aimed to model the spatial distribution of the epidemiology of the coronavirus in Iran using spatial statistics. The application of Moran's index to analyze the spatial distribution of the coronavirus revealed that the primary geographical factor contributing to the spread of the virus in the country was the proximity and distance between the affected provinces, aligning with the observed pattern of spatial diffusion [29-31]. As the above studies show, an internal study on the relationship between diabetes and urbanization has not been done. Most of the studies on this issue focus on biomedical and genetic factors concerning the incidence and prevalence of diabetes, while largely neglecting the influence of social, cultural, and overall urban lifestyle factors.

2. Materials and Methods

In this article, the researchers used GIS to understand the spatial difference in the incidence of diabetes. They collected relevant information and created a database in ArcCatalog. Using spatial statistics tools in ArcMap, they evaluated the spatial pattern and relationships between variables at the city level. The method employed in this study was considered more efficient compared to other spatial regression methods [32]. To analyze the distribution pattern of diabetes in Zanjan, the researchers employed Moran's spatial correlation. This method takes advantage of the fundamental principles of geography, including proximity and connection. It examines the strength, weakness, or randomness of the relationship and correlation between spatial positions and the desired feature. Unlike other spatial autocorrelation tools that solely analyze the distribution pattern or characteristic values of complications, Moran's spatial correlation evaluates the distribution pattern of complications by simultaneously considering the spatial position and the desired feature. The results of this analysis reveal whether the distribution pattern of complications appears random, scattered, or clustered in space [33]. Statistics I is calculated based on the concept of covariance and weighting based on the proximity of sample points (ground observations) as follows:

Relation No. 1:

$$I = \frac{n\sum_{i=1}^{n}\sum_{i=1}^{n} w_{ij}\,(x_i-\bar{x})(x_j-\bar{x})}{\left(\sum_{i=1}^{n}\sum_{i=1}^{n} w_{ij}\right)\sum_{i=1}^{n}(x_i-\bar{x})^2}$$

In the function above, n is the area number, x_i is the variable amount in the area i, $x_j$is the variable amount in the area j, $\bar{x}$ is the variable mean in the whole area, w_{ij} is the employed weight for comparing i and j areas. In the next step, to analyze the spatial instability of the data and the spatial changes of the relationships between the spatial data, the geography-weighted regression (GWR) method was used to estimate the relationships between the variables from one place to another [20]. The geographic weighted regression method is an analysis and explanation of the spatial instability of data and the analysis of spatial changes in the relationships between spatial data. Spatial instability shows that the measurement or estimation of relationships between variables differs from one place to another (in the OLS method, these measurements are constant). The GWR method has overcome this problem by producing and providing location information in which changes can also be seen. This method produces a separate regression equation for each observation, so it makes it possible for the parameter values to change continuously in the geographical space. Each of the equations is analyzed using a different weight from other observations [20]. In this method, the following formula is used to estimate the coefficients of two independent variables X_1 and X_2:

Relation No. 2:

$$z(s_i) = \beta_0(s_i) + \beta_1(s_i) + \beta_2(s_i) + x_2 + \varepsilon$$

In the above relationship, Si represents the position of the i-th place, Z represents the dependent variable, and X1 and

X2 represent the independent variables. The important point in the model is that the independent and dependent variable coefficients are a function of the position or situation (S_i) of the observations and the value of the independent variable β is different from one position to another. To estimate the coefficients in the GWR method, the following relationship is employed:

Relation No. 3:

$$\hat{\beta}(s_i) = (x^T W(s_i) X)^{-1} x^T W(s_i) z$$

In the mentioned relationship, W represents the weight matrix, which is calculated based on the observation distance and bandwidth. In general, it can be said that the analysis of information in this study is divided into two categories: cluster analysis and regression modeling. In the first group, the approach of exploratory analysis of spatial data has been used. Individuals with diabetes in 2018 along with demographic data and statistical blocks of 2018 were used as the base year of this research. In the regression modeling to descale the raw data of diabetes, the number of observed cases was divided into age groups above 18, and then the incidence rate of diabetes was obtained for health measurement sites at the city level using the geographic weighted regression method. In the regression modeling of the incidence of diabetes as a dependent variable and type of economic activity, education level, overweight, and access as independent variables were evaluated to test the effect of environmental exposures on the prevalence of diabetes.

2.1 Study area

Zanjan Medical Sciences Health Unit monitors the urban health status of citizens through 18 centers and health assessment bases in two sections of communicable and non-communicable diseases. According to the Vice President of Health at Zanjan University of Medical Sciences and Health Services, the prevalence of diabetes among individuals over 25 years old in the province was reported to be 7.2 % in 2015, while this rate was 10.8 % in the country. Moreover, findings from the survey on risk factors of non-communicable diseases revealed that the percentage of diabetic patients was 60 % in the province and 74 % in the country. Additionally, the survey indicated the percentage of overweight and obese individuals was 56 % in the country and 55 % in the province, with higher rates observed among women compared to men. More than 7.2 % of the people of Zanjan province are suffering from diabetes, with Base 2, Center 17 recording the highest frequency of diabetes cases (319 cases), while Base 3, Center 9 reported the lowest incidence (76 individuals) according to data from the Zanjan Medical Sciences Health Unit.

3. Results and Discussion

Hot spots refer to relatively positive spatial autocorrelation in the frequency of a complication. It looks at each complication in the framework of the complications that are in its neighborhood. In cold spots, the goal is to find areas that have unexpectedly low values compared to other variables. Figure 1 shows the hot and cold spots in the spatial distribution of diabetes in Zanjan City. As this figure shows, the incidence of diabetes follows a relatively random pattern in a few areas. The cold spots of urban diabetes are primarily located in the south, southwest, and central parts of the city. The north-east and north-west regions show the highest incidence of diabetes at a significant level of 99 % confidence. These areas correspond to Koi Farhang, Elahia, Durmangah, Golshahr, Zibashahr, and Basic Sciences areas.

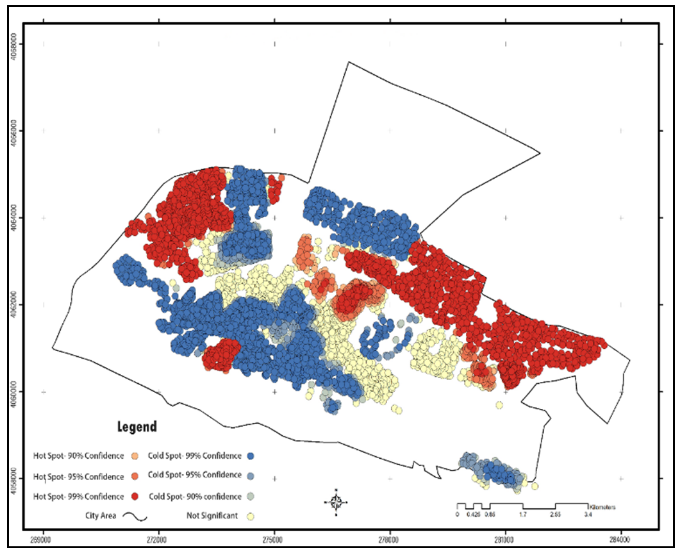

Figure 1. Hot and cold spots of diabetes spatial distribution in Zanjan City

3.1 Diabetes′ Spatial Transmittance in Zanjan City

The analysis further highlights the cluster pattern of diabetes incidence in Zanjan City (Figure 2). In total, there are more cold spots than hot spots in the city. Therefore, the zero hypothesis of the random spatial distribution pattern of diabetes with a significance of 0.000 at the 99 % confidence level, the z-statistic of 108.2 shows high clustering with Moran's index of 1.16 in Zanjan City. The low value of the expected index shows that any changes in the process would result in a shift from a random distribution pattern to a clustered one. Investigating the effective processes of the cluster pattern of diabetes needs serious discussion based on local information. Given that the prevalence of diabetes depends on the size and population structure of the localities, indirect standardization has been used in this research. The standardization rate is obtained according to the average age groups living in urban areas. Regression modeling of the level of education demonstrates a positive and strong relationship at a 95 % confidence level in Kuy-e-Farhang, Elahiye, Sarjangaldari, Bissim, and Trans neighborhoods. In contrast to the central part of the city, Golshahr Phase I, Quds, and North Saadi exhibit a negative and strong relationship at a 95 % confidence level, between educational level and the prevalence of diabetes in Zanjan City.

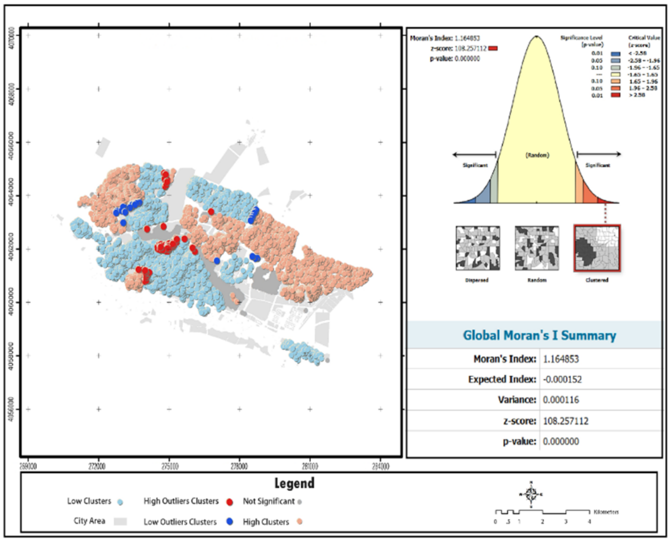

Figure 2. Map of intensity and weakness of diabetes clusters in Zanjan City

Figure 3 and Figure 4 present the predicted values of weighted geographic regression for diabetes based on the investigated variables. The findings indicate a significant and positive relationship between economic activity type and diabetes prevalence in Darmangah, Shahrak Shohada, Qeisarieh, Bazaar neighborhood, Hosseinieh, and Payin Kouh neighborhoods. On the other hand, a strong and negative significant relationship can be seen in the neighborhoods of Shahrara, Etemadieh, and Bisim.

Figure 3. Map of observed values of household economic and social base and diabetes in Zanjan City

The detailed results of this modeling (Table 1) show that there is a significant and direct relationship between the prevalence of diabetes and those working in the arts and entertainment, transportation, and food industries. That is, the prevalence of diabetes is more observed in areas where people work in these occupational groups. The transportation sector exhibits the highest coefficient (3.51) with a significance level of 0.000. A significant and inverse relationship is observed between the employees of the education sector and diabetes, with a coefficient of -1.5 with a significance level of 0.000. No significant relationship is found between diabetes incidence and other occupational groups in Zanjan City. The statistical analysis of educational level shows a significant and inverse relationship between diabetes prevalence and individuals with diplomas (1.5) and sub-diplomas (4.07). In the neighborhoods where citizens with diplomas and sub-diploma reside; the incidence and prevalence of diabetes is more expected. The important point is that the prevalence rate of diabetes in Zanjan neighborhoods does not decrease with an increase in the level of university education, contrary to expectations. The statistical analysis indicates a numerical value of -1.7 in citizens with more than a master's degree, with a significance level of 0.000.

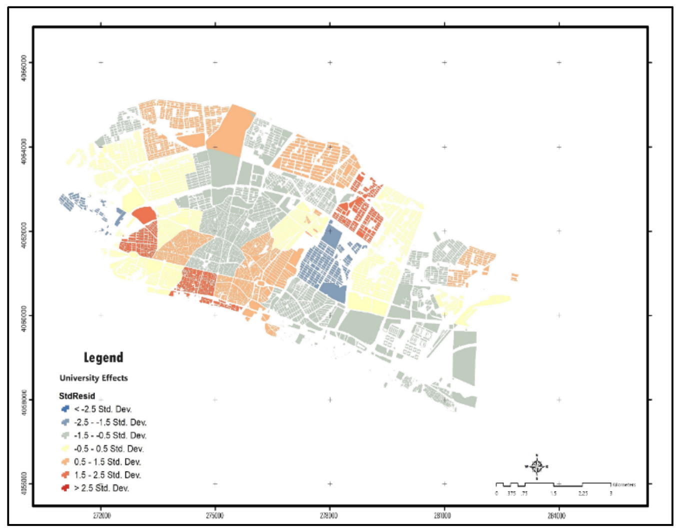

Figure 4. Map of predicted values of household economic and social base and diabetes in Zanjan City

Table 1. Regression modeling of diabetes prevalence rate in Zanjan City in terms of occupational groups and educational level

		Coefficient	*p-value*
Education	Under Diploma	4.07	< 0.001
	Diploma	1.55	< 0.001
	Undergraduate	-0.15	< 0.001
	Master's and above	-1.75	< 0.001
Occupation	Employees of the education	-1.50	< 0.001
	Employees of the entertainment	2.51	< 0.001
	Employees of the transportation	3.51	< 0.001
	Employees of the food sector	2.01	< 0.001

4. Conclusion

The biomedical approaches to disease management have caused a significant reduction in mortality and morbidity worldwide. However, these approaches often ignore the strong effects of culture, society, and environment on the individual's health. In the face of a widespread issue such as diabetes, disregarding the impact of cultural and social factors is not only not permissible but also misguided and inaccurate. Although cities are categorized by distinctions and differences, the research findings presented in this study are also very efficient for other urban environments and provide a platform for the development of local practical solutions in other cities. The findings of this research show that in Zanjan City, the prosperous urban areas have an upward trend in the incidence of diabetes. This finding is contrary to the research results reported by Holm *et al.* (2015). However, the cluster pattern of diabetes in Zanjan City is consistent with the findings of IDF reports (2015) [32]. Furthermore, this research supports the significant relationship between occupational groups and the prevalence of diabetes in Zanjan City, as previously reported by CCD (2020) [18]. Contrary to the findings of Holm *et al.* (2015), the effect of education level in reducing the incidence and prevalence of diabetes in Zanjam City was confirmed. In contrast to the findings of Kyobutungi (2008), the research does not establish a relationship between population density in low-lying areas and the prevalence of diabetes in Zanjan City [1]. In general, it can be said that the prevalence of diabetes in Zanjan City has a cluster pattern where most of the cold clusters correspond to the lower urban areas. The north-east and north-west of the city show the highest incidence of diabetes at a significant level of 99 % confidence. These areas correspond to Koi Farhang, Elahia, Durmangah, Golshahr, Zibashahr, and Basic Sciences areas. There are more cold spots than hot spots in the city. Regression modeling reveals a strong and positive correlation, at a 95 % confidence level, between the prevalence of diabetes and the level of education in neighborhoods such as Koi Farhang, Elahia, Sarjangaldari, Bissim, and Trans. Conversely, a negative and significant relationship is observed, at the same confidence level, between education level and diabetes prevalence in Golshahr Phase I, Quds, and Saadi North neighborhoods. Furthermore, the type of economic activity demonstrates a substantial and positive correlation with diabetes in neighborhoods such as Darmangah, Shahrak Shohada, Qeisarieh, Bazaar neighborhood, Hosseinieh, and Payin Kouh. Conversely, a strong and negative significant relationship is evident in Shahrara, Emetadieh, and Besim neighborhoods. The important point is that contrary to expectations, the prevalence rate of diabetes in Zanjan neighborhoods does not decrease with higher levels of university education.

Authors' Contributions

Shahrzad Moghadam, Isa Piri: Investigation; Writing-original draft; Writing-review and editing. The authors read and approved the final version.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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Ethical considerations

All ethical principles are considered in this article.

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