Is the location of Public Health Units in Curitiba meeting the citizens' needs?

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Abstract. Guaranteeing adequate health services to the population is a challenge, especially in developing countries where limited resources must be optimized in order to reach a larger portion of the population. To properly assess the adequacy of health services and prioritize new investments, it is important to gather a large amount of relevant data, integrated from various sources.

This paper presents an ongoing research focusing on Curitiba, one of the largest cities in Brazil. We have aggregated socio-political, geographical, transportation and health data from open repositories in order to understand the dynamics of how citizens choose their health units when required, as well as verify the availability of bus stops close to these units. The paper reports findings from our exploratory analysis, highlighting the cases where the city's administration is on the right track, but also the areas which require more investment. More specifically, using GIS and Data Analysis tools we analyze the occurrence of medical appointments made outside of the citizens' residential neighborhood and the most frequent diseases they had. We also detail which health units do not have a bus stop in a determined radius.

Keywords: Open Data, Urban Planning, Health Units, Georeferenced Data.

1 Introduction

As the city grows and health units, bus lines, and its bus stops are implemented, it is important to assess whether the infrastructure can cope with the increasing demand of its population; what was a good distribution of services in terms of urban planning in the recent past may no longer satisfy the citizens' needs. Geographic Information Systems (*SIGs*) can assist in this type of analysis, as long as there is sufficient and reliable data being generated by the responsible institutions.

According to [ZIVIANI et al 2015], there are many mobility models that are used to describe or predict urban mobility, but most of them use a single source of data to do such analysis. Therefore in this article, we bring a new analysis based on different data sources, being them: health units' location, patients' residence location and availability of bus stops near the health units.

Curitiba is the capital and the largest city of the Brazilian state of Paraná, one of the three states that comprise Brazil's South Region. It is also the eighth most populous city in the country. As highlighted at [NAKONETCHNEI et al 2017], Curitiba has been participating in open data initiatives along with several government stakeholders, such as *Instituto de Planejamento de Curitiba* (IPPUC)[1] and the Municipality of Curitiba through its Open Data Portal[2]. Open data information is collected, processed and maintained by the city administration to be freely used by the society and republish as desired, without restrictions from copyright, patents or other mechanisms of control. In this scenario, we explore the data about medical appointments from public Health Units of Curitiba and correlate with the city's georeferenced data. More specifically, regarding the neighborhood where the patients reside versus the neighborhood of the health units chosen for their medical appointments and procedures, categorizing the most frequent diseases these patients had when the medical appointment took place. We also review the availability of bus stops close to the public health units. The source of the georeferenced data regarding bus stops, bus stations, and health units' location is IPPUC.

The remaining work in this paper is organized as follows: Section 2 details the data and tools used. Location analysis of the Health Units is presented in Section 3, Limitations are described in Section 4, and finally, conclusion and future work are presented in Section 5.

2 Data and Tools

This Section details the analyzed data, where it was found and the challenges faced to put it together, going through the tools used to review it.

According to data from the Health Department[3], the Unified Health System of Curitiba has a network of 216 units distributed as described in Table 1 across its 75 neighborhoods. For this paper, we obtained the dataset of medical services performed in three types of health units, namely: Emergency Care Units, Basic Health Units, and Medical Specialty Centers.

Table 1. Types of Health Units from Curitiba.

Unit Type	N. of Units
Basic Health Units (BHU)	109
Health Spaces	68
Psychosocial Attention Centers (PSAC)	12
Emergency Care Units (ECU)	9
Medical Specialty Centers	5

[1] http://ippuc.org.br/ Last accessed 10-May-2018

[2] http://www.curitiba.pr.gov.br/DADOSABERTOS/ Last accessed 10-May-2018

[3] http://www.saude.curitiba.pr.gov.br/a-secretaria/historico-da-secretaria.html, last accessed 18-April-2018.

Therapeutic Residences	5
Dental Unit Centers	3
Hospitals	2
Clinical Analyses Laboratory	1
Central of Vaccines	1
Zoonose Centre	1

Using data from the same Health Department that is available on Curitiba Open Data Portal, from January-2017 to December-2017, except for February-2017 due to the data being incorrectly formatted (apparently due to an export error), it was found that 3,086,518 medical appointments were performed from 23 different medical procedures. Figure 1 shows the numbers of appointments by month, on average there were 280,525 appointments each month in 2017. January was the month with the lowest number of appointments and October the month with the highest number, but in general, the number of appointments is quite constant throughout the year.

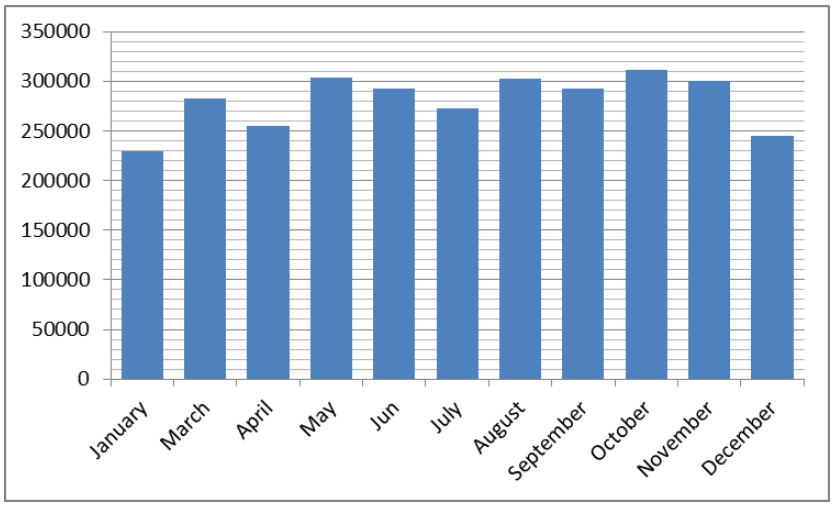

Figure 1. Number of medical appointments by month in 2017

Also according to information from the Department of Transportation[4], Curitiba has 250 bus lines. As prospected by [KOZIEVITCH et al 2016], the city has 9,940 bus stops within the stationary data. It also has an additional bus stop category named Tube Bus Stations (in Portuguese, Estação Tubo). The tube stations (officially 342) are bus stops which look like tubes, for specific bus routes, such as *Expresso* and *Linha Direta*. The neighborhoods named *CIC* and *Centro* have the majority of them,

[4] https://www.urbs.curitiba.pr.gov.br/institucional/urbs-em-numeros, last accessed 08-April-2018.

with a total of 1,628 and 667 each one. It also has 23 bus terminals and one intercity/ interstate terminal which also offers train services.

As we reviewed the data for the medical appointments in order to understand the origin of the people that use the medical system, we discovered that it contains only the neighborhood of the patient. Based on that, we decided to use this field as the person's origin location, even though some neighborhoods are quite large such as CIC. In Table 2 we describe the most important fields available on the medical appointment source files - in total it has 37 fields so we suppressed the ones that are not relevant for this study.

Table 2. Database table *atendimento_unidade_saude.*

Column Name	Description
Dt_atendimento	Date when the medical appointment occurred.
Cod_unidade	Code of the Health Unit
Desc_unidade	Description of the Health Unit
Cod_procedimento	Code of the medical procedure executed
Desc_procedimento	Description of the procedure executed
Cod_cbo	Code of the professional occupation
Desc_cbo	Description of the professional occupation
Cod_cid	International Classification of Diseases Code
Desc_cid	International Classification of Diseases Description
Cid_internamento	International Classification of Diseases of hospitalization
Municipio	City of the patient
Bairro	Neighborhood of the patient

Table 3. Database table *unidade_de_saude.*

Column Name	Description
Cd_equip	Code of the health unit
Nome_abrev	Short name of the health unit
Nome_mapa	Nome of the health unit on the map
Cd_bairro	Code of the neighborhood
Bairro	Neighborhood
Quadr_equi	Block of the health unit
Cd_regiona	Code of the Regional
Regional	Regional
Func_manha	Whether or not it is open in the morning
Func_tarde	Whether or not it is open in the afternoon
Func_noite	Whether or not it is open at night
Func_24hr	Whether or not it is open 24 hours a day
Desativado	Whether or not it is disabled
Coord_e	Coordinate e
Coord_n	Coordinate n
Geom	Geometry

Table 4. Database table *atendimento_join_unidades_de_saude.*

Column Name	Description
Cd_equip	Code of the health unit
Desc_unidade	Description of the health unit
Cod_unidade	Code of the health unit

The data was imported to a table created on a PostgreSQL[5] server with spatial extension PostGIS[6], in which georeferenced data provided by IPPUC from the public health units of Curitiba was already stored, as well as information of the city's bus stops and terminals.

One issue that we experienced was that the medical appointments table and the medical units table do not share the same identifier. The medical units table stores the geospatial location of the units and is detailed in Table 3. Based on that we decided to use the unit names to link both, however, the names were not matching due to issues with accentuation and small variations of the name. Due to that we had to create an association table as detailed in Table 4 and link them both mostly manually. It was also found that one unit was missing as it had been inaugurated recently - thus we had to georeference it and add to the table. When georeferencing it we found out that the column used to store the spatial data (column named *geom*) is configured using projection ESPG 4326, but the data on it is really on ESPG 29192[7] projection, so we had to convert the data that we had to suit that.

Subsequently, for the integration and visualization of the georeferenced data, we used QGIS[8] software, versions 2.14.11 (Essen) and 2.18.18(Las Palmas). Additionally, to generate a complex network graph we used Gephi[9] 0.9.2 software.

3 Location analysis of the Health Units

In our initial study, we analyzed the distribution of the public health units by neighborhoods in the city of Curitiba, and it was verified that of the 75 existing neighborhoods in Curitiba, 33 of them do not have a health unit. Most of these 33 neighborhoods, in which there are no health units, are those with the highest income per household, according to data presented in the economic profile report published by Curitiba Agency[10]. On the other hand, in 29 neighborhoods there are 2 or more health

5 https://www.postgresql.org, last accessed 08-April-2018.
6 https://postgis.net, last accessed 08-April-2018.
7 http://spatialreference.org/ref/epsg/sad69-utm-zone-22s-2/, last accessed 15-May-2018.
8 https://www.qgis.org/en/site/, last accessed 14-May-2018.
9 https://gephi.org/, last accessed 14-May-2018.
10 http://www.agencia.curitiba.pr.gov.br/arquivos/regionais/perfil-economico-regional-matriz.pdf, last accessed 08-April-2018.

units, and the Industrial District of Curitiba (CIC) has the highest number of health units (a total of 16).

Using heat maps it is possible to confirm the distribution of the health units across the city and relate it to the neighborhoods and income. In Figure 2 it is possible to see the distribution of the population according to data from the 2010 census[11]. As a comparison, on Figure 3 the heat map shows the medical appointments per health units, and there is a notable overlap between Figures 2 and 3. Additionally, there is an empty space around the center of them that is filed in Figure 4, which shows a heat map of income per household. Therefore, by looking at those maps it is confirmed that the appointments at health units and the units themselves are located closer to the population with the lowest income.

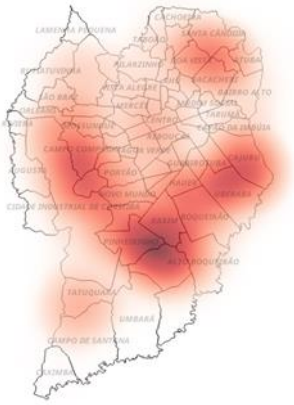

Figure 2. Population by neighborhood

Figure 3. Total medical appointments per health units

Figure 4. Higher Income per household

Regarding the existence of bus stops near the health units, a radius of 200 meters was taken into account for this analysis; it was found that 6 health units neither have a bus stop nor a bus station within the radius of 200 meters. These 6 health units are BHU Umbará, BHU Vila Leão, BHU Luiz L. Lazof / Vila Esperança, BHU Pompéia , ECU Boqueirão and ECU Pinheirinho. They are highlighted as yellow triangles in Figure 5, all other health units are shown as red triangles and the bus stops near them are presented as black spots. Figure 6 shows a histogram with the distance of the health units to bus stops.

[11] http://www.ippuc.org.br/nossobairro/nosso_bairro.htm, last accessed 20/05/2018.

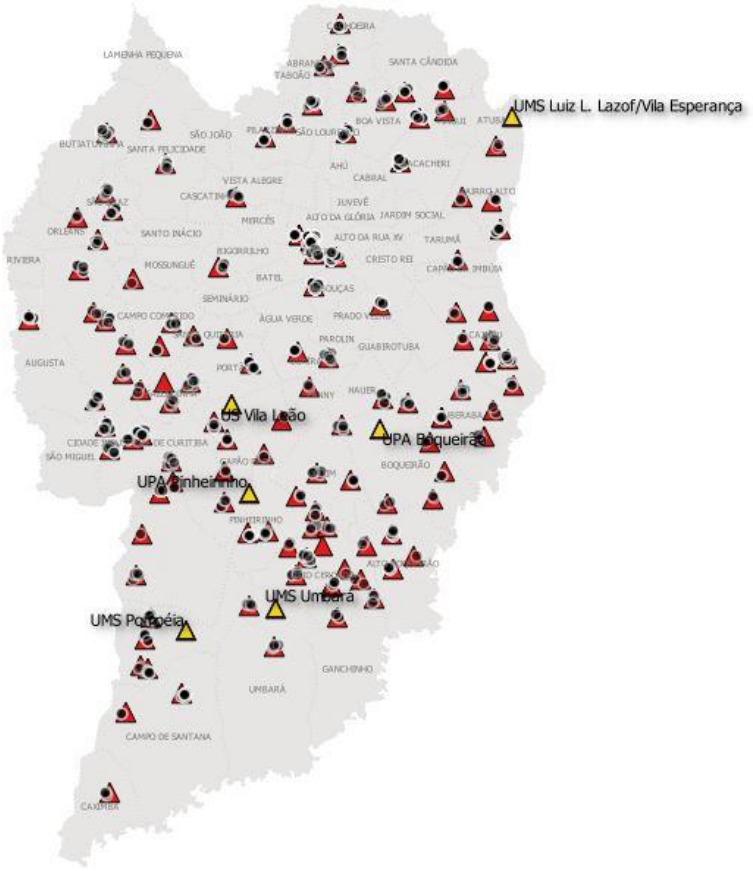

Figure 5. Health Units and bus stops within a radius of 200 meters.

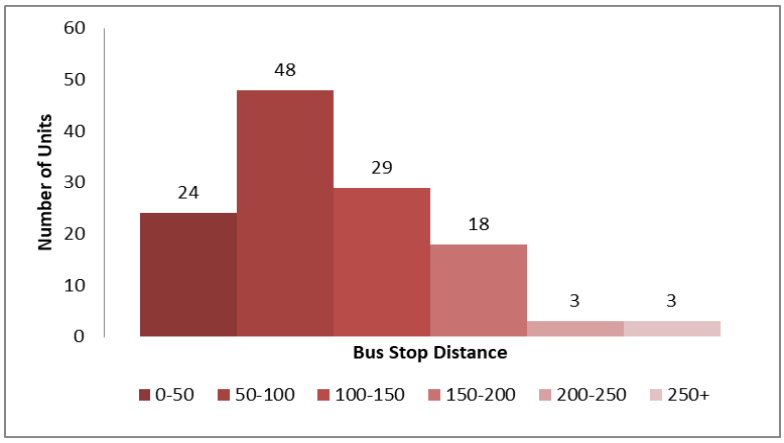

Figure 6. Histogram showing the distance of the HU to the bus stops in meters

It was verified that 12.34% of the 3,086,518 medical appointments made during the analyzed period were performed outside the neighborhood where the patients reside – it means that a daily average of 1,130 people went to another neighborhood to have a medical appointment. Figure 7 shows the displacement made by the patients from their residential neighborhood to the 5 most visited health units by patients from outside the neighborhood where the unit is located. These 5 most visited health units are emergency care units (ECU) that provide service 24 hours a day, being: Cajuru, Boqueirão, Boa Vista, Campo Comprido and Sítio Cercado. Figure 7 shows a complex network graph which highlights the intensity of the flow for those patients who had their medical procedures outside their residential neighborhood - thicker lines represent a greater flow of people. Looking at the numbers of those 5 units, a total of 28.64% of the medical appointments (184,392 appointments out of 643,764) were performed by people from other neighborhoods.

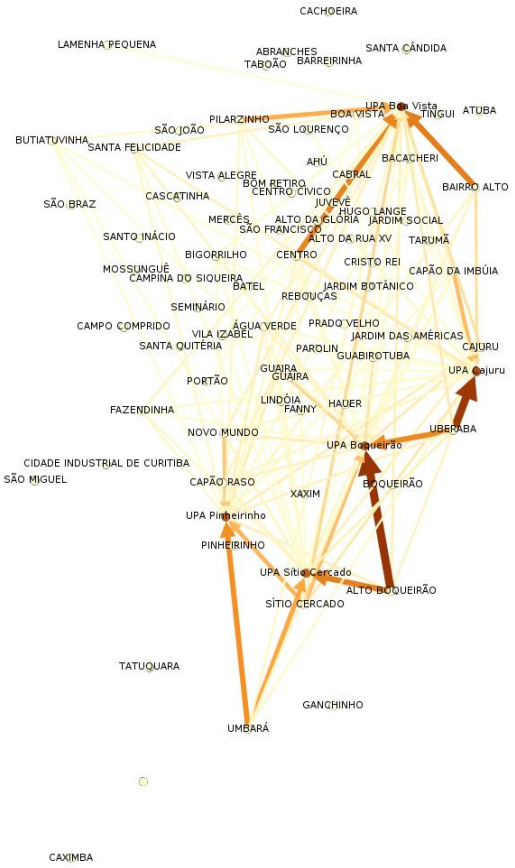

Figure 7. The 5 Health Units most visited by patients from other neighborhoods.

It is interesting to note that ECU Boqueirão is one of the top 5 that most receive people from other neighborhoods but it does not have a bus stop in the 200 meter area.

We also reviewed the top 5 International Classification of Diseases (ICD) codes for these medical visits performed outside the patients' residential neighborhood, comparing them to the 5 ICD codes of all the medical visits present in the data set for comparison purposes:

Table 5. Comparison of top 5 ICD between all the medical visits and medical visits performed outside the patient's residential neighborhood.

All medical visits	**Total**	**Top-5 outside the residential neighborhood**	**Total**
General Medical Examination	309366	Acute upper respiratory infections, unspecified	14512
Issue of Repeat Prescription	174749	Acute tonsillitis, unspecified	9229
Acute upper respiratory infections , unspecified	124942	Acute nasopharyngitis [common cold]	8969
Essential (primary) hypertension	108797	General Medical Examination	8309
Acute nasopharyngitis [common cold]	95349	Other gastroenteritis and colitis of infectious and unspecified origin	8098

Based on this information, it is possible to notice that the great majority of the medical visits made outside the patients' residential neighborhood consist of complications of the respiratory tract, which usually get aggravated at night. To confirm this information, the time of these medical visits were checked as seen in Figure 8. The numbers on the left represent the number of medical appointments in the blue line and the numbers on the right represent the number of medical appointments in the red line. In summary, this analysis points out that the number of medical visits is constant from 14:00 to 23:00 in the top 5 health units visited by patients from other neighborhood, while the number of general medical appointments drops sharply after this period. Figures 9 shows the number of appointments by hour per day of the week for all health units while Figure 10 shows the same view but only for the top 5 health units visited by patients from other neighborhoods.

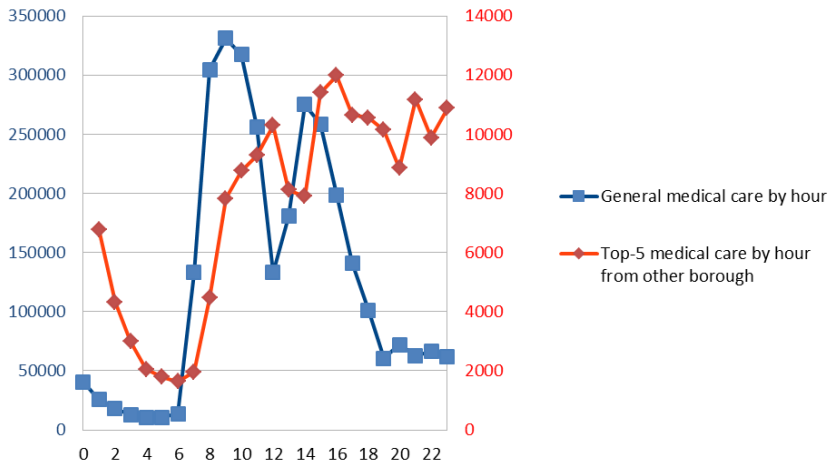

Figure 8. Time comparison of general medical visits and top 5 health units visited by patients from other neighborhood.

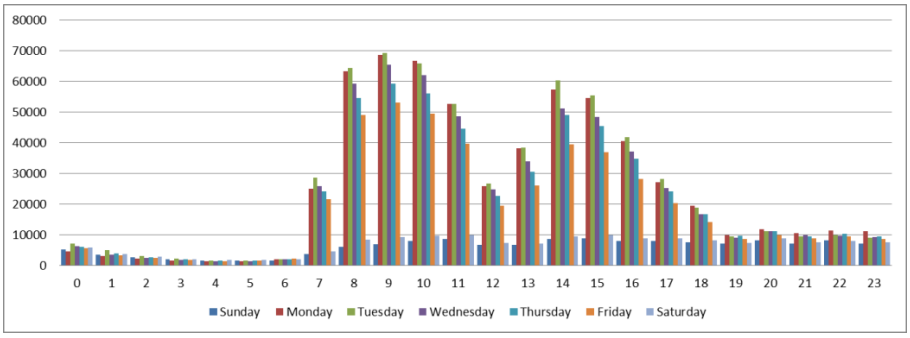

Figure 9. Number of appointments by hour per day of the week for all health units.

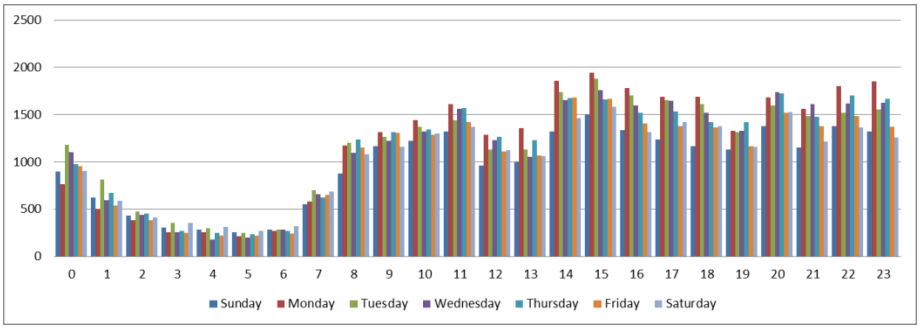

Figure 10. Number of appointments by hour per day of the week for top 5 health units visited by patients from other neighborhoods.

4 Limitations

A number of issues were encountered throughout this work, especially in terms of data consistency and integrity. The first issue was with the open data set of medical appointments for the month of February 2017 - as mentioned in Section 2; a great amount of the data for this specific month had missing columns which prevented us from using it.

As stated in Section 2 another issue was that the open data of the medical appointments and the database table containing the health units' geolocation did not share the same identifier; therefore it was required extensive manual work to correlate both data sets using the name of the health units: the first data set was not using accent and the second was, additionally there were a few names mismatch as well.

Regarding the bus stop data used, although the data showed there was no bus stop in the 200 meters radius of ECU Pinheirinho, google maps shows a bus stop almost in front of the ECU Pinheirinho.

In summary, the main challenge faced throughout this work was regarding data consistency among the different sources of data.

5 Conclusion

The objective of this research was to understand the medical appointments at public health units in Curitiba and relate this information to their locations, bus stops and displacements performed by the citizens to arrive at the health units.

In a preliminary analysis, it can be understood that the bus stops are well located and allow citizens to arrive at the majority of health units without the need of long walks, fulfilling its function of being located where the population needs. But it is also observed that there is a relevant amount of displacements from outside the citizens' neighborhood to the top 5 ECU, especially looking for treatment of respiratory problems – it is required further research on related works and with the municipality of Curitiba to understand if those numbers are expected and why.

In future work it would be possible to validate whether not only the destination is in the correct location but whether the origin and bus routes are addressing this need of the population who are more distant from health units - or even assess whether these health units are in the correct location and the reason why citizens are looking for them instead of going to the nearest units. Additionally, it is intended to use Google Map review data about the health units and analyze the data using Collective intelligence approaches.

Curitiba municipal government could use the results of this research to assess whether the different data sources administered by the city can be normalized in order to facilitate future researches. Other studies using data from different cities could use the numbers from this paper as a baseline for comparison.

Acknowledgments

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