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A Comparative Performance Analysis of Türkiye's Health System within OECD Countries

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ABSTRACT

A country's healthcare system represents one of its most vital infrastructures, profoundly impacting the well-being of its citizens. Examining key performance indicators (KPIs) helps policymakers understand the complex nature of the health system and identify areas for improvement. This paper provides a comparative performance analysis of Türkiye's health system compared to other Organization for Economic Co-operation and Development (OECD) countries. An Output-Oriented Categorical Data Envelopment (CAT-DEA) model is used, and K-means clustering were applied for categorizing countries based on health expenditures. In this study, inputs include health expenditure, availability of doctors and nurses, and hospital beds, while outputs consist of life expectancy at birth and citizen satisfaction with healthcare services. The efficiency scores of 36 OECD countries were calculated, and 6 of them were found to be efficient. However, the analysis shows that higher health expenditures, while placing countries in higher categories, do not necessarily correlate with greater efficiency scores. Therefore, policymakers should not rely solely on increasing per capita health expenditure as a strategy to improve efficiency;

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it must be paired with effective resource allocation to enhance system performance.

Keywords: Categorical DEA, Efficiency Analysis, Efficiency Measurement, Healthcare KPIs, Health System Performance

INTRODUCTION

The World Health Organization (WHO) defines a health system as all organizations, people, and actions whose primary purpose is to promote, restore, or maintain health. According to the Organization for Economic Co-operation and Development (OECD), a health system is the combination of all organizations, people, and resources whose primary purpose is to promote, restore, or maintain health within a specified population, usually within a country and bounded by national borders (OECD, 2023). Both definitions focus on the country-wide boundary of a health system that carries characteristics of complex systems as they consist of various stakeholders, organizations, and numerous functions (Yesilsirt et al., 2022). The complex nature of the health system also challenges the country's policymakers to improve the outcomes of the health system. Examining specific key performance indicators of the health system can assist policymakers in gaining deeper insights into its internal capacities and identifying areas for improvement. Unexpected disasters, with their recent global-scale impacts, have invariably affected health system performance. In the context of Data Envelopment Analysis (DEA), efficiency is defined as the performance of the Decision-Making Unit's (DMU) ability to maximize outputs relative to given inputs or minimize inputs for a desired level of output. DEA determines relative efficiency by comparing DMUs with similar input-output structures and assigning an efficiency score based on this relationship. Therefore, we focus on a comprehensive review of existing literature on performance analysis of healthcare systems, data collection and analysis, and performance evaluation using the categorical DEA model.

In health systems-related literature, there are various frameworks to evaluate health systems performance. In this study, two of these frameworks are referred to better understand the performance evaluation of health systems. Among these are the WHO's Monitoring Six Building Blocks (World Health Organization, 2007; World Health Organization, 2010) and the OECD's "As-

sessing Health System Performance" (Figueras et al., 2024). OECD is a global organization that collects, analyzes, and publishes health system-related data to provide insights to its member countries. The OECD's 'Health at a Glance' reports, initiated in 2001, provide extensive data on population health and system effectiveness across member and emerging economies. The health data shown in Figure 1 covers "health status", "risk factors for health", "access to and quality of healthcare", and "health system resources" (OECD, 2023). WHO releases health data with various indicators on its website, known as the Global Health Observatory (GHO). The GHO issues analytical reports on the current situation and trends for priority health issues. A key output of the GHO is the annual publication World Health Statistics, which compiles statistics for key health indicators on an annual basis are shown in Figure 2.

Health Status	Risk Factors of Health	Access to Care	Quality of Care	Health System Capacity and Resources
Life expectancy - years of life at birth Avoidable mortality - preventable and treatable deaths (per 100,000 people, age-standardised) Chronic conditions - diabetes prevalence (% adults, age-standardised) Self-rated health - population in poor health (% population aged 15+)	Smoking – daily smokers (% population aged 15+) Alcohol - liters consumed per capita (population aged 15+), based on sales data Obesity – population with body mass index (BMI) ≥30 (% population aged 15+) Ambient air pollution - deaths due to ambient particulate matter, especially PM2.5 (per 100,000 people)	Population coverage, eligibility – population covered for core set of services (% population) Population coverage, satisfaction - population satisfied with availability of quality healthcare (% population) Financial protection - expenditure covered by compulsory prepayment schemes (% total expenditure) Service coverage - population reporting unmet needs for medical care (% population)	Safe primary care - antibiotics prescribed (defined daily dose per 1,000 people). Effective primary care - avoidable hospital admissions (per 100,000 people, age- and sex-standardized) Effective preventive care - mammography screening within the past two years (% of women aged 50–69) Effective secondary care - 30-day mortality following acute myocardial infarction and ischemic stroke (per 100 admissions for people aged 45 and over, age- and sex-standardized)	Health spending - total health spending (per capita, USD using purchasing power parities) Health spending - total health spending (% GDP) Doctors - number of practicing physicians (per 1,000 people) Nurses - number of practicing nurses (per 1,000 people) Hospital beds - number of hospital beds (per 1,000 people)

*OECD (2023), Health at a Glance 2023: OECD Indicators, OECD Publishing, Paris, http://doi.org/10.1787/7a7afb35-en.

Figure 1. Indicators used by OECD (OECD, 2023)

HEALTH SYSTEM PERFORMANCE INDICATORS

HEALTH FINANCING	HEALTH WORKFORCE	HEALTH SERVICE DELIVERY
Domestic general government health expenditure (GGHE-D) as percentage of general government expenditure (GGE) (%) External health expenditure (EXT) as percentage of current health expenditure (CHE) (%) Domestic general government health expenditure (GGHE-D) as percentage of general government expenditure (GGE) (%) Current health expenditure (CHE) as percentage of gross domestic product (GDP) (%) Domestic private health expenditure (PVT-D) as percentage of current health expenditure (CHE) (%) Current health expenditure (CHE) per capita in US$ Domestic general government health expenditure (GGHE-D) as percentage of gross domestic product (GDP) (%) Out-of-pocket expenditure as percentage of current health expenditure (CHE) (%) Domestic general government health expenditure (GGHE-D) as percentage of current health expenditure (CHE) (%) External health expenditure (EXT) per capita in US$ Domestic general government health expenditure (GGHE-D) per capita in US$ Domestic private health expenditure (PVT-D) per capita in US$ Out-of-pocket expenditure (OOP) per capita in US$	Nursing and midwifery personnel (per 10,000 population) Nursing personnel (number) Nurses by sex (%) Midwifery personnel (number) Nursing and midwifery personnel (number) Environmental and Occupational Health and Hygiene Professionals (number) Environmental and Occupational Health Inspectors and Associates (number) Community Health Workers (number) Medical doctors (per 10,000 population) Medical doctors not further defined (number) Generalist medical practitioners (number) Medical doctors (number) Specialist medical practitioners (number) Medical doctors by sex (%) Medical and Pathology Laboratory Technicians (number) Medical and Pathology Laboratory scientists (number) Pharmacists (per 10,000 population) Pharmacists (number) Pharmaceutical Technicians and Assistants (number) Dentists (number) Dental Assistants and Therapists (number) Dentists (per 10,000 population) Dental Prosthetic Technicians (number) Physiotherapy Technicians and Assistants (number) Physiotherapists (number) Traditional and Complementary Medicine Professionals (number)	Hospital beds (per 10,000 population) Care-seeking by type of patient and source of care (%)

Figure 2. Indicators used by WHO (World Health Organization, 2024)

Based on these indicators, both OECD and WHO reports were analyzed, and the capacity of the health system is conceptualized through resources such as financing and the health workforce. This paper is organized as follows: The first part provides a background on measuring the performance of healthcare systems and KPIs of the health system's capacity and resources to construct a DEA evaluation framework. The second part presents studies on health system performance and efficiency analysis. The third section applies the DEA model and framework, followed by the concluding discussion.

LITERATURE REVIEW

The literature review is conducted in stages, beginning with exploring health system performance metrics, efficiency frameworks, and KPIs. As indicated, the indicators from WHO and OECD were examined. To find indicators in this study, we focused on methodologies for assessing health systems' capacity and resources, particularly through DEA. Recent studies on performance measurement and efficiency analysis provided a conceptual basis for this research.

Data Envelopment Analysis has been widely employed for decades to evaluate health system efficiency due to the complex nature of healthcare, which often involves multiple inputs and outputs (Po et al., 2009). Various articles have focused on different indicators to determine the effectiveness of the health system. Afonso & Aubyn (2005) used "hospital beds per 1000 people" and "number of doctors and nurses per 1000 population" as inputs and "healthy life expectancy" as output to determine health system efficiency with DEA. Kocaman et al. (2012) used inputs including "number of physicians per thousand people", "number of hospital beds per thousand people", "health expenditure per capita", "share of gross domestic product (GDP) allocated to health expenditures", "number of magnetic resonance imaging (MRI)", and the "rate of smoking population" to determine the effectiveness of the health system of 36 OECD countries. Life expectancy at birth and the mortality rate under five years are selected as outputs and measured by DEA. Cetin & Bahce (2016) assessed the efficiency of health systems in 36 OECD countries using input-oriented DEA analysis, employing doctors, patient beds, and health expenditure per capita as inputs, and life expectancy and infant mortality rates as outputs. The efficiency of 36 OECD countries' health systems is assessed using DEA, which included fourteen inputs (pharmaceutical consumption, average years of schooling, obesity, tobacco consumption, alcohol consumption, per capita health expenditure, percentage of health care expenditure, physicians, nurses, beds); and four outputs (life expectancy, infant mortality, population aged, and population aged 65 years and older) (Behr & Theune, 2017). The performance of 31 OECD countries' health systems is assessed using health system indicators, including the number of doctors, hospital beds, and health expenditures, as well as external variables such as GDP, population behavior, and socioeconomic factors. As a result, external determinants exert a stronger

influence on efficiency than health considerations (Hadad et al., 2013). In a recent study, by Lupu & Tiganasu (2022), thirty-one European countries' health systems efficiencies are analyzed during the COVID-19 Pandemic. Seven major fields of influence are considered: healthcare resources, health status, population, economic, cultural, societal, and governmental issues, all covering fifteen indicators.

METHODOLOGY

DEA is a method that was first created using a single input and a single output in 1957 in Michael J. Farrell's study on efficiency analysis. It is a non-parametric technique based on linear programming. This technique compares the performance of DMUs according to a predetermined definition of efficiency. It expresses whether DMUs are effective among themselves. The DMU is considered effective when compared to other, less efficient DMUs. One type of DEA model, developed by Charnes, Cooper, and Rhodes (CCR), assumes that production has constant returns to scale (CRS), meaning any change in the input will result in a proportionate change in the output (Ahmed et al., 2019; Charnes et al., 1978). Another model proposed by Banker, Charnes, and Cooper (BCC) suggests that production functions on variable returns to scale (VRS), which means that changes in input might result in either an increase or a drop in output. The CCR methodology is especially valuable for this study since it measures the effectiveness of organizational units or the health systems of various nations (Ahmed et al., 2019; Banker et al., 1984; Kim & Kang, 2014). DEA models typically assume homogeneous, controllable variables within DMUs, though some external factors may impact results.

The Categorical DEA was created by Banker and Moorey in 1986 as a DEA model that views uncontrolled variables as categorical variables. In this manner, the categorical variable will be used to separate the DMUs whose efficiency scores are to be computed into subgroups, and these sub-homogenous groupings will be considered while doing efficiency studies. For DEA analysis, two oriented models are the input and output-oriented models. An output-oriented DEA model aims to maximize the outputs with a given number of inputs, while input-oriented models focus on minimizing the inputs used to obtain a certain amount of output (Ahmed et al., 2019). The output-oriented method

was used for this study because outputs such as life expectancy and citizen satisfaction with the healthcare system are desired to be increased. The related mathematical formulation of the Categorical DEA model is shown in Figure 3.

Output-Oriented Categorical CCR Model

Objective Function

Max θ

Constraints

$$\sum_{j \in U_f^L} \lambda_j x_{ij} \leq x_{ik}, \forall i$$

$$\theta y_{rk} - \sum_{j \in U_f^L} \lambda_j y_{rj} \leq 0 \ \forall r$$

$$\lambda_j \geq 0, \forall j \in U_f^L$$

Notations

L= Category level

x_{ij}= Amount of input i used by DMU j

y_{rj}= Amount of output r produced by DMU j

λ_j=Weight assigned to DMU j in forming the reference set for the target DMU

θ = Efficiency score of the DMU under evaluation

x_{ik}= Amount of input i produced by DMU k

y_{rk}= Amount of output r produced by DMU k

U_f^L = Index of DMUs included under category L

Figure 3. Output-Oriented Categorical CCR Model (Taşköprü, 2014)

Data Collection

Hence, the efficiency assessment in this study will be undertaken using the most recent available data. Although data from 2021 or 2022 exist for certain criteria, the evaluation will mostly focus on 2021 data, the most recent accessible period, due to partial data and the unavailability of numerous variables. The data utilized in this analysis are derived from the World Health Organization's publication. The definitions of the selected inputs and outputs are shown in Table 1.

Table 1: Description of input and output variables

Inputs	Definition	Data	Data Source
Health Expenditure	Current health expenditure per capita in US$	2022	OECD Health Stat.
Number of Doctors	Practicing doctors per 100 000 population	2021	OECD Health Stat.
Number of Nurses	Practicing nurses per 100 000 population	2021	OECD Health Stat.
Number of Hospital Beds	Hospital beds include all inpatient beds for use per 100 000 population	2021	OECD Health Stat.
Outputs	**Definition**	**Data**	**Data Source**
Life Expectancy	The average number of years that a person might reasonably be expected to live at that age is known as life expectancy at birth	2021	OECD Health Stat.
Citizens Satisfaction with the Health System	Citizen satisfaction with the health system reflects the public's assessment of healthcare quality	2020	OECD Health Stat.

Determining Categories for DEA

The K-means clustering method, which groups DMUs based on similarities, is used in this categorical DEA study to establish categories. Countries were categorized into five categories based on the 2022 per capita health expenditure values. Values are divided into clusters using average expenditure values. It clarifies the link between efficiency scores and health resources.

RESULTS

Table 2, demonstrates that a country's health expenditure level, as indicated by its expenditure category, does not necessarily determine its technical efficiency score. For instance, the United States, with the highest health expenditure and classified in Category 5, holds a ranking of 1, indicating a technical efficiency score of 1. This same ranking and technical efficiency score are shared by countries like

Türkiye, Colombia, and Mexico, which belong to Category 1 with considerably lower health expenditure. Similarly, Luxembourg and Canada, in Category 3 with moderate spending, also achieve a ranking of 1 with a technical efficiency score of 1. This highlights that while expenditure level influences category placement, it does not directly correlate with technical efficiency rankings or scores.

Table 2: List of the countries' level category

Rank	DMU
Category 5	
1	United States
Category 4	
21	Norway
22	Switzerland
28	Germany
35	Austria
Category 3	
1	Luxembourg
1	Canada
7	Belgium
8	Japan
10	United Kingdom
11	Finland
12	Netherlands
14	Sweden
15	Denmark
17	New Zealand
19	Iceland
20	France
23	Australia
25	Ireland

Rank	DMU
Category 2	
9	Korea
13	Slovenia
16	Israel
24	Spain
26	Italy
Category 1	
31	Czech Republic
34	Portugal
36	Lithuania
1	Türkiye
1	Colombia
1	Mexico
18	Chile
27	Estonia
29	Hungary
30	Poland
32	Slovak Republic
33	Greece

The efficiency of the health systems of 36 OECD member countries was evaluated using the same methodology under the output-oriented CCR model shown in Table 3. By applying the output-oriented CCR model, the analysis emphasized output maximization relative to the available inputs, providing a comprehensive assessment of the efficiency levels across all 36 OECD members. The United States, Luxembourg, Canada, Türkiye, Colombia, and Mexico's efficiency score equals one, which means they have efficient health systems. These six countries use their resources efficiently and provide health services at an optimum scale. Contrarily, the remaining countries have efficiency scores lower than one. According to the model, they are not efficient.

Table 3: Ranking of efficiency scores of 36 OECD countries

Rank	DMU	Score	Rank	DMU	Score
1	United States	1	19	Iceland	0.7910
1	Luxembourg	1	20	France	0.7791
1	Canada	1	21	Norway	0.7578
1	Türkiye	1	22	Switzerland	0.7425
1	Colombia	1	23	Australia	0.7408
1	Mexico	1	24	Spain	0.7180
7	Belgium	0.9894	25	Ireland	0.6965
8	Japan	0.9849	26	Italy	0.6623
9	Korea	0.9746	27	Estonia	0.6588
10	United Kingdom	0.9439	28	Germany	0.6577
11	Finland	0.9424	29	Hungary	0.6549
12	Netherlands	0.9317	30	Poland	0.6373
13	Slovenia	0.9297	31	Czech Republic	0.6148
14	Sweden	0.9283	32	Slovak Republic	0.6131
15	Denmark	0.9111	33	Greece	0.5621
16	Israel	0.9095	34	Portugal	0.5602
17	New Zealand	0.8664	35	Austria	0.5569
18	Chile	0.8305	36	Lithuania	0.4821

Furthermore, Figure 4 shows the efficiency scores of health systems across countries divided into three main continents: America, Europe, and Asia-Oceania. The efficiency scores of 36 OECD countries' health system performances, using different colors, indicate different levels of efficiency. The color gradient from light to dark blue represents efficiency scores, countries with greater efficiency scores are shaded darker, while those with lower scores are shown in lighter. In the Americas, countries like the United States, Canada, and Mexico are darker than Chile, indicating that these countries have achieved relatively higher health system efficiency. In Europe, countries such as Luxembourg and Türkiye exhibit the highest efficiency scores with the darkest shading. Other European countries, Greece, Portugal, Austria, and Lithuania, fall into the inefficiency range, represented by a lighter color. In Asia-Oceania, Australia is indicated by the lighter shading, while Australia and Japan demonstrated darker.

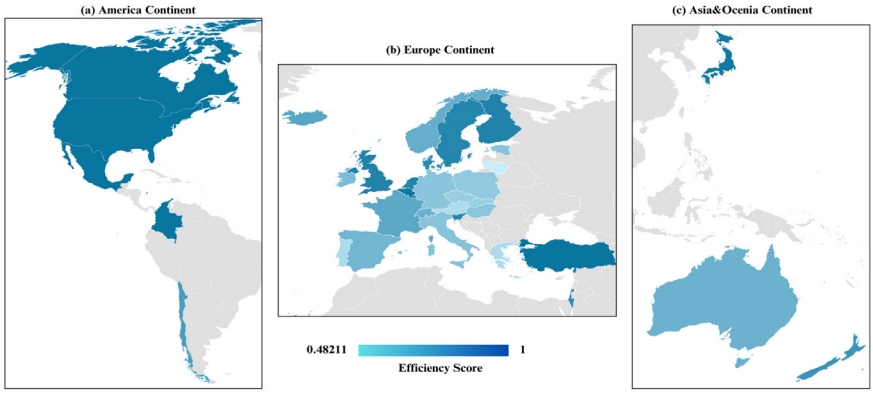

Figure 4. Colored map of the efficiency scores of the selected 36 OECD countries

The quadrant chart in Figure 5 compares the health expenditure per capita in US dollars and the efficiency scores of countries. Each country is represented by a point on the chart, with the y-axis representing efficiency scores and the x-axis representing health expenditure per capita. The graph is split into four quadrants to make it easier to distinguish between high and low-spenders and high and low-efficiency performers. The countries' health systems in the top-right quadrant are well-funded and efficient, as evidenced by their high expenditures and high efficiency. In contrast, the bottom-left quadrant demonstrates low efficiency and spending, indicating potential areas for improvement in health expenditure and management.

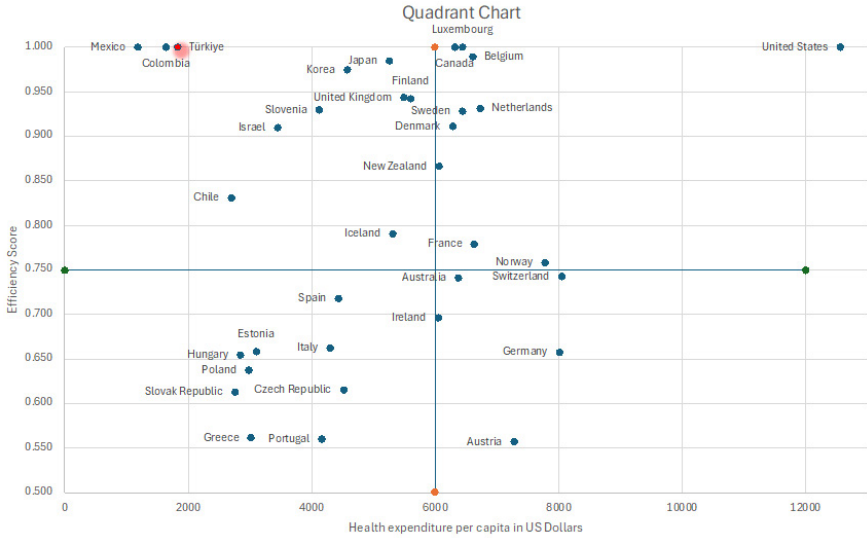

Figure 5. Quadrant chart of efficiency score and health expenditure

DISCUSSION

The results show that there are significant differences in the health system performance across OECD countries. For instance, Türkiye has the lowest number of practicing doctors per 100,000 population at 218, whereas Greece has the highest at 629. Similarly, Colombia has the fewest nurses at 159 per 100,000 population, while Finland leads with 1,892. This disparity mirrors the workforce availability findings in the study and emphasizes the critical impact of workforce distribution on system efficiency (Lupu & Tiganasu, 2022). This indicates significant inequalities in health expenditure, workforce distribution, and health outcomes across OECD countries. The United States leads in per capita health expenditure, which correlates with its high-efficiency score. Conversely, the efficiency scores of Norway, Switzerland, Germany, and Austria are lower than one. Therefore, they are not efficient even if they are in Category 4, which means they have higher health expenditure per capita than the rest of the countries except the United States. These results confirm that increased health expenditure does not necessarily guarantee greater efficiency, consistent with findings of the study that highlight that countries with moderate spending can achieve high efficiency through optimal resource utilization (Afonso & Aubyn, 2005). Therefore, while health expenditure is crucial,

converting this expenditure into high system performance through effective resource allocation is even more critical. Countries in the top-right quadrant in Figure 5 such as the United States, Belgium, and the Netherlands, can maintain high efficiency despite high spending, showing a well-funded and efficient system. In contrast, nations in the bottom-left quadrant, such as Greece and Portugal, face spending and efficiency difficulties, emphasizing possible areas for policy intervention to improve health system performance.

CONCLUSION

This research aimed to measure the efficiency of the health systems performance of 36 OECD countries as a benchmark to improve Türkiye's health system. According to the current literature and to the best of our knowledge, this study demonstrates academic originality by employing the CAT-DEA method to evaluate 36 OECD countries.

In this study, appropriate input and output variables were first identified for analyzing the healthcare systems of OECD countries. A thorough literature review was conducted to select the variables, and the most recent data were utilized to create a comprehensive dataset. To categorize the countries, k-means clustering was applied based on their health expenditure per capita, resulting in five categories. Following this, an output-oriented categorical DEA was performed using these categories. As a result of this analysis, six out of the 36 countries were found to be efficient. It was observed that the efficiency scores of these countries were not directly related to their category values, which were determined by health expenditure per capita. The results suggest that higher health spending alone does not guarantee efficiency; thus, policymakers should not rely solely on increasing per capita health expenditure to enhance efficiency. In addition to financial investment, attention must be given to other factors that contribute to healthcare system efficiency. Specifically, investments should also be directed toward addressing input or output variables where certain OECD countries fall below the average. For instance, Türkiye, achieving a high-efficiency score shows high performance in the health system, but increasing inputs such as the number of doctors below the OECD average is of great importance in maintaining and increasing the efficiency score.

Moreover, the findings of this research paper will provide inputs towards an ongoing research study focused on measuring the "adaptive" and "resilient" capacities of Türkiye's health system. By examining the adaptability of the health system in the face of unexpected events, this research will offer critical insights. These insights will serve as a foundation for evaluating current strategies and developing new approaches that strengthen the system's overall resilience and adaptability.

Ethical Approval: Not applicable.

Authors' Contributions: KÇ, ÖE, and MAK planned study design. ÖE and KÇ conducted the literature review. MAK constructed the method, and KÇ applied Categorical Data Envelopment Analysis. All the authors participated in the results and discussion. All authors read and approved the final version of the manuscript.

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