Brief Report

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Exploring the determinants that influence end-of-life hospital costs of the elderly in Shanghai, China

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Summary **The aim of this study was to use data from the Information Center of the Shanghai Municipal Commission of Health and Family Planning (SMCHFP) to determine the factors affecting end-of-life hospital costs of patients. A total number of 43,806 decedents who died in medical facilities in 2015 were examined. These individuals, accounted for 34.85% of all deaths in 2015 in Shanghai. Descriptive analysis and multiple linear regression analysis were performed using STATA 13.0. Results indicated that 88.94% of the decedents who died in medical facilities were over age 60. Males accounted for 55.57% of decedents, and the insured were mostly covered by Urban Employee Basic Medical Insurance (UEBMI) (81.93%). Cancer and circulatory disease were the main causes of death, causing 34.53% and 26.19% of deaths. Hospital costs were higher for males (male *vs*. female: 9,013 USD *vs*. 7,844 USD), individuals insured by UEBMI (8,784 USD), and individuals with cancer (10,156USD). Twenty-nine-point-zero-three percent of admissions occurred in the month before death and accounted for 37.82% of costs. Multiple linear regression analysis indicated that hospital costs were correlated with gender, cause of death (cancer, circulatory disease, or respiratory disease), time-to-death, insurance schemes, level of medical facilities, and length of stay (LOS) ($p < 0.05$ for all). After controlling for other factors, age was not a significant factor ($p > 0.05$). A proximity-to-death (PTD) phenomenon was evident in Shanghai. This study suggested that the PTD should be considered when predicting medical cost. Primary medical care should be enhanced and gaps in insurance coverage should be reduced to improve the efficiency and equity of medical funding. More attention should be paid to the population with a heavier disease burden.**

Keywords: Proximity to death, hospital costs, multiple linear regression analysis

1. Introduction

According to population sample surveys conducted by the Bureau of Statistics of Shanghai, 12.32% of residents were over age 65 in 2015; this proportion is projected to rise to 14.81% in 2020 and to 32.97% in 2050 (*1*). A study has plotted health care costs with respect to age and used age-cost curves to quantify the relationship between age and health care cost (*2*). Average per capita health care cost for Americans age 65 and older was more than triple that for a benchmark group (ages 34-44) in 1999 (*3*). Per capita spending for the elderly was about 5 times higher than spending for children (*4*). Thus, health policymakers are concerned about how smaller numbers of younger people and increased numbers of elderly will affect health care cost.

Recent studies have argued that approaching death, rather than age, is the demographic driver of health care costs because of a proximity-to-death (PTD) phenomenon. PTD refers to the fact that terminal patients are likely to use more healthcare resources, resulting in higher healthcare expenditures, than survivors use (*5-10*). The 'terminal' period varies from 1 to 5 years (*10-12*). According to Zweifel, Felder, and Meiers, the high

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mortality rate of the elderly and tremendous end-of-life medical costs leads to the "inconvenient fact" of PTD, which is that population aging has increased overall medical cost (*10*). Most studies have concluded that age was less influential than PTD (*5,11-13*), though a few studies that controlled for time-to-death found that prolonged life expectancy was still a factor influencing the increase in medical cost (*14*).

Other factors including gender, type of insurance, type of disease, and care received have been examined as predictors of medical cost. Some evidence has shown that males have greater total medical cost per inpatient and a longer length of stay (LOS) (*15*) since traditional Chinese culture values males over females, but other evidence has shown that women have higher health care cost in general and are closer to death (*16*). The PTD phenomenon has been noted in most diseases. The cost before death are highest for cancer and lowest for cardiovascular diseases (*7,17*). A previous study indicated that patients' LOS and inpatient costs varied depending on their health insurance and hospital stay. Uninsured patients had lower cost (*18*). Place of discharge was associated with hospital costs (*12*).

Health care cost as a result of population aging are mostly attributable to higher mortality rates in combination with high costs of dying. A better understanding of the costs of dying is crucial to curbing health care costs as a result of population aging (*19*). However, few studies have examined the determinants of end-of-life medical cost in China due to a lack of data. Thus, the aim of the current study was to investigate whether PTD exists in Shanghai and to identify the factors that influence hospital costs in Shanghai. The findings should help policymakers improve the provision of medical care to the elderly.

2. Subjects and Methods

2.1. *Subjects*

Data were collected from the Information Center of the Shanghai Municipal Commission of Health and Family Planning and cover all admissions to any medical facility and all age groups in the population of Shanghai. A total of 43,812 decedents died in medical facilities between January 1, 2015 and December 31, 2015. Six decedents were hospitalized for longer than 2 years in a single stay and were excluded as subjects. Hence, a total number of 43,806 decedents served as subjects. These individuals accounted for 34.85% of all deaths in 2015 in Shanghai. The inpatient care received and its cost were tracked for 2 years before death. All records were coded for an individual using an identification number. Other information from medical records included age, gender, type of basic medical insurance, diagnosis, date of admission and discharge, and cost of medical care.

2.2. *Dependent variables*

The dependent variable was hospital costs of decedents. Hospital costs 2 years prior to death were calculated.

2.3. *Independent variables*

Demographic indicators: Demographic factors including age and gender were examined as potential determinants of hospital costs.

Cause of death: The cause of death was identified based on the latest record of admission for each decedent. The International Classification of Diseases (ICD-10) was used to classify a decedent's disease.

Time-to-death: The time prior to death was calculated in months. The inpatient care received and its cost were tracked separately 24 months before death.

Related indicators of medical care received: Related indicators of medical care received included the type of insurance scheme, the level of the medical facility, and LOS. Insurance schemes were classified as Urban Employee Basic Medical Insurance (UEBMI), Urban Resident Basic Medical Insurance (URBMI) and New Rural Cooperative Medical Insurance System (NCMS), or other types. 'Other' types of insurance schemes mostly referred to a state medical scheme (covering senior officials) or a supplementary medical insurance scheme, which provides greater reimbursement for the insured. Medical facilities were divided into municipal hospitals (tertiary hospitals), district hospitals (most were secondary hospitals), or primary care facilities (most were community health service centers). LOS was included in the model as a continuous variable.

2.4. *Statistical analysis*

Multiple linear regression analysis was performed to simulate hospital costs with a set of explanatory variables including age, gender, cause of death, time-to-death, type of insurance scheme, the level of medical facility, and LOS. The least sum of squares method was used to estimate the quantitative relationship between the dependent variable *hospital cost* and explanatory variables. The model is shown below:

$$\ln Y_{exp} = \beta_0 + \beta_1 A + \beta_2 G + \beta_3 Cau + \beta_4 TTD + \beta_5 Ins + \beta_6 Lev + \beta_7 Los + \varepsilon$$

where A denotes calendar age in years and Los denotes the actual length of stay of inpatients. G was a dummy variable for gender (0 if female and 1 if male). Cau referred to cause of death (otherwise = 0 as the benchmark) and Ins referred to the type of insurance scheme (otherwise = 0 as the benchmark), and the two were included in the model as nominative variables. Lev indicated the level of medical facility, which was included as an ordinal variable; a primary care facility

served as the benchmark.

Since hospital costs had a skewed distribution, a logistic conversion was applied. All statistical analysis was performed using STATA 13.0. A significance level of 0.05 was used for hypothesis testing. All Chinese currency figures in this study were adjusted to comparable prices in USD using the average exchange rate in 2015 (6.2284 RMB = 1 USD).

3. Results and Discussion

In this study, 43,806 inpatients were examined, of whom 88.94% were over the age of 60. Males accounted for 55.57%, and the insured were mostly covered by UEBMI (81.93%). Cancer (34.53%), circulatory disease (26.19%), respiratory disease (22.44%), and gastrointestinal disease (4.94%) accounted for 88.10% of all causes of death. The average hospital cost per person in the last 2 years was 13,893 USD, and the average LOS was 95 days (Table 1).

Table 1. The age, gender, cause of death, TTD, and related indicators of medical care received by decedents in Shanghai, China in 2015 (*n* = 43,806)

Indicators	Values
Age (Mean ± SD)	77.32 ± 12.81
Gender (*n* (%))	
Male	24,343 (55.57)
Female	19,463 (44.43)
Cause of death (*n* (%))	
Cancer	15,128 (34.53)
Circulatory disease	11,472 (26.19)
Respiratory disease	9,829 (22.44)
Gastrointestinal disease	2,162 (4.94)
Other cause	5,215 (11.90)
Insurance Scheme (*n* (%))	
UEBMI	35,891 (81.93)
URBMI	4,786 (10.93)
NCMS	1,136 (2.59)
Other type	1,993 (4.55)
LOS (Mean ± SD)	95.19 ± 145.73
Hospital costs (Mean ± SD)	13, 893.46 ± 19,425.47

LOS, length of stay; NCMS, New Rural Cooperative Medical Insurance System; SD, standard deviation; TTD, time-to-death; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance. Other types of insurance schemes mostly referred to a state medical scheme or a supplementary medical insurance scheme.

As shown in Figure 1, more than half of the admissions (59.73%) during the last 2 years of life were to district hospitals and 33.26% were to municipal hospitals. Thirty-seven-point-two-four percent of hospital costs were incurred in municipal hospitals, 58.76% were incurred in district hospitals, and 4.00% were incurred in primary care facilities. Seven-point-zero-two percent of inpatient care provided at primary care facilities was for terminal elderly patients, compared to 2.60% of the total elderly population when survivors were included. The figures indicated that patients were more likely to visit primary care facilities at the end of their life.

3.1. *Hospital costs by population groups*

Per capita hospital costs did not increase with age. On the contrary, individuals ages 25-29 had the highest cost (up to 31,941 USD per capita). The interval hospital costs per capita of the elderly age 60 or older were 12,165 USD to 16,380 USD, and the average cost for the elderly were 13,487 USD in the last 2 years of life, as shown in Figure 2. The high average cost for the elderly was probably due to their high mortality rate, though end-of-life care is costly regardless of whether a patient is age 40 or age 70 (*11-13*). In fact, costs were greater for younger age groups than for older age groups.

One hundred and seventy-four thousand, thirty-one hospital records were examined for 2 years before decedents died. Twenty-nine-point-zero-three percent of admissions occurred in the month before death, and those

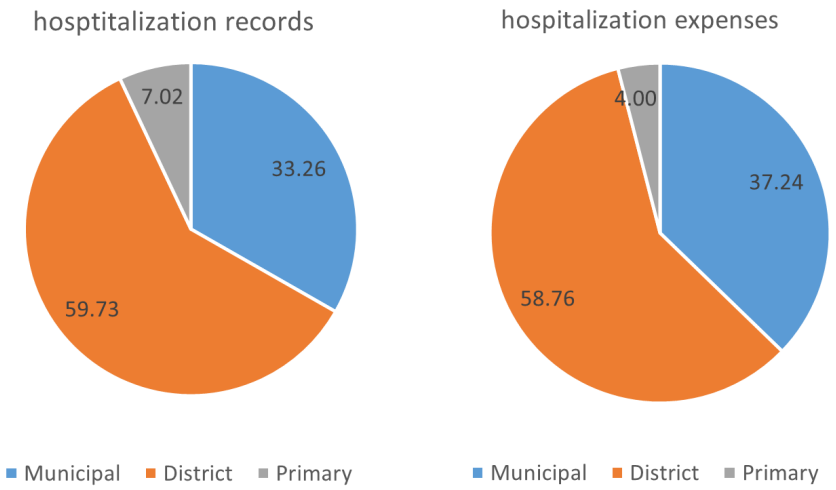

Figure 1. Hospital records and costs during the last 2 years of life in medical facilities in Shanghai, China in 2015.

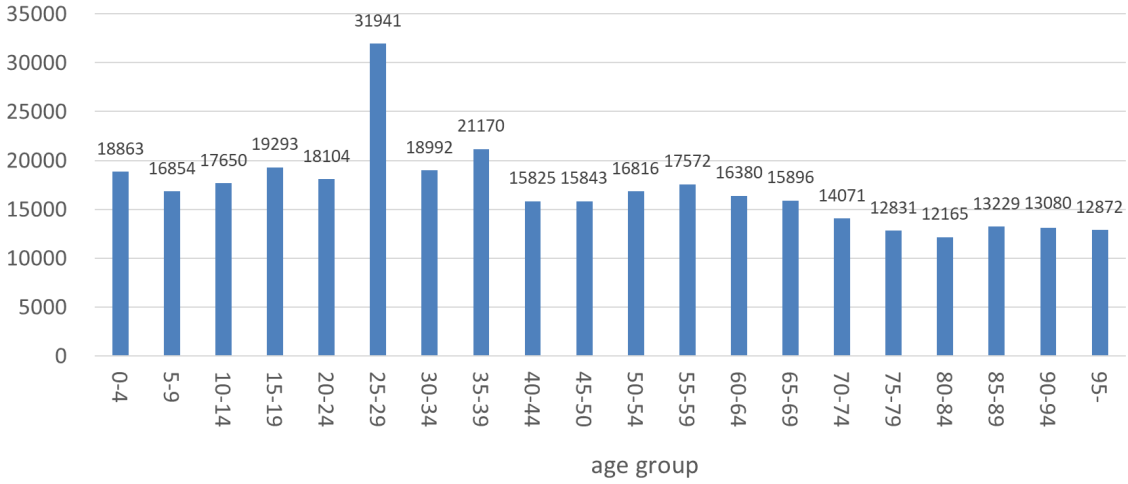

Figure 2. Hospital costs per decedent in the last 2 years of life by age in Shanghai, China in 2015 (USD).

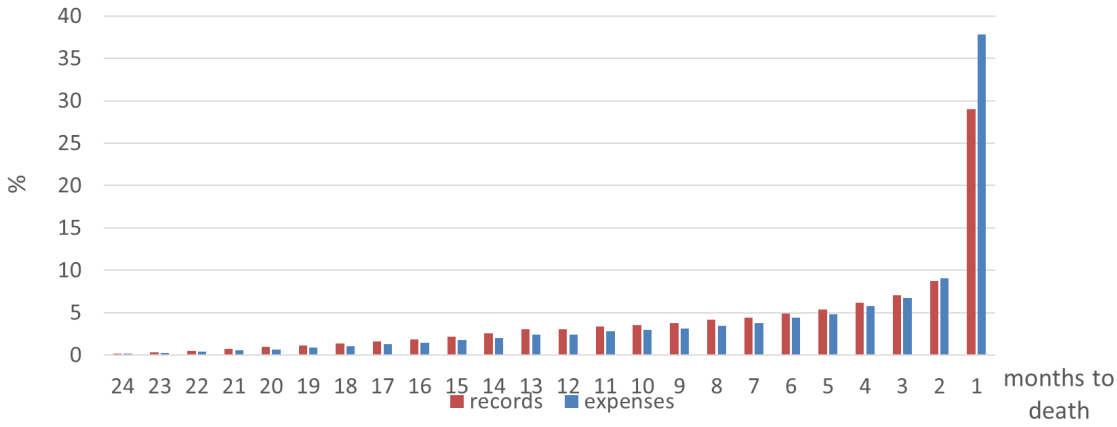

Figure 3. Hospital records and costs in the last 24 months in Shanghai, China in 2015.

Table 2. Hospital records and costs in the last 24 months of life in Shanghai, China in 2015

Months to death	Monthly cost (USD)	Cumulative proportion (%)	Hospital records	Cumulative proportion (%)
1	230,200,255	37.82	50,527	29.03
2	55,215,780	46.90	15,241	37.79
3	40,948,190	53.62	12,257	44.83
4	34,955,633	59.37	10,687	50.97
5	29,322,976	64.19	9,409	56.38
6	26,635,464	68.56	8,544	61.29
7	22,767,909	72.30	7,708	65.72
8	21,075,637	75.77	7,250	69.89
9	19,149,939	78.91	6,583	73.67
10	17,818,905	81.84	6,134	77.19
11	17,269,843	84.68	5,915	80.59
12	14,744,503	87.10	5,359	83.67
13	14,603,365	89.50	5,252	86.69
14	12,284,234	91.52	4,444	89.24
15	10,608,182	93.26	3,783	91.41
16	8,944,79	94.73	3,249	93.28
17	7,769,126	96.01	2,823	94.90
18	6,557,102	97.08	2,339	96.24
19	5,271,144	97.95	1,912	97.34
20	4,155,078	98.63	1,611	98.27
21	3,528,526	99.21	1,248	98.99
22	2,363,562	99.60	850	99.48
23	1,538,910	99.85	570	99.81
24	887,818	100.00	336	100.00

Table 3. Average hospital costs by population groups in Shanghai, China in 2015 (USD)*

Population groups	Mean	*P*25	*P*50	*P*75
Gender (per capita)				
Male	15,075	3,866	9,013	18,282
Female	12,415	3,284	7,844	16,050
Cause of death (per capita)				
Cancer	15,031	4,632	10,156	19,707
Circulatory disease	12,390	3,052	7,478	15,162
Respiratory disease	14,424	3,160	7,592	16,305
Gastrointestinal disease	12,150	3,344	7,642	14,630
Other cause	13,625	3,106	7,925	16,508
Insurance Scheme (per capita)				
UEBMI	13,336	3,836	8,784	17,489
URBMI	9,592	2,572	6,071	12,671
NCMS	5,280	1,241	3,411	6,833
Other type	39,165	6,238	18,053	51,748
Level of the medical facility (per day)				
Municipal hospital	420	169	260	446
District hospital	221	109	168	256
Primary care facility	41	21	32	49

NCMS, New Rural Cooperative Medical Insurance System; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance. Other types of insurance schemes mostly referred to a state medical scheme or a supplementary medical insurance scheme.
*P*25 refers to the first quartile, *P*50 refers to the median and *P*75 refers to the third quartile.
*Because of the abnormal distribution of hospital costs, *P*50 was used to reflect average hospital costs.

Table 4. Results of multiple regression analysis of the determinants of hospital costs in Shanghai, China in 2015

Indicators	β	95% Wald CI	*p* value
Age	0.0007	(-0.0000-0.0014)	0.055
Gender (Female *vs*. Male)	0.0320	(0.0176-0.0470)	0.000
Cause of death			
Cancer (Cancer *vs*. other causes)	-0.9010	(-0.1167--0.634)	0.000
Circulatory disease (Circulatory *vs*. other causes)	0.0326	(0.0046-0.0606)	0.023
Respiratory disease (Respiratory *vs*. other causes)	0.0730	(0.0445-0.1014)	0.000
Gastrointestinal disease (Gastrointestinal *vs*. other causes)	0.0066	(-0.0346-0.0478)	0.753
Time-to-Death	-0.0183	(-0.194--0.0172)	0.000
Insurance schemes			
UEBMI (UEBMI *vs*. NCMS)	0.3116	(0.2604-0.3630)	0.000
URBMI (URBMI *vs*. NCMS)	0.2612	(0.2075-0.3149)	0.000
Other (Other *vs*. NCMS)	0.7536	(0.6922-0.8152)	0.000
Level of the medical facility			
Municipal (Municipal hospital *vs*. Primary care facility)	1.2956	(1.2641-1.3272)	0.000
District (District hospital *vs*. Primary care facility)	1.1707	(1.1409-1.2004)	0.000
LOS	0.0100	(0.0097-0.1025)	0.000

LOS, length of stay; NCMS, New Rural Cooperative Medical Insurance System; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.

stays accounted for 37.82% of cost. In cumulative terms, 44.83% of records and 53.62% of cost were from the last 3 months before death, as shown in Figure 3 and Table 2. Inpatient care and hospital costs abruptly increase closer to death.

Average hospital costs by population groups are shown in Table 3. Total hospital costs for males were 9,013 USD, which were higher than those for females (7,844 USD) in the last 2 years of life. This finding is consistent with the results of related domestic studies (*15,20,21*). More attention needs to be paid to gender equity in health. Patients with cancer incurred the most costs (10,156 USD) while patients with respiratory diseases incurred the least (7,592 USD). Compared to other types of insurance schemes, NCMS provided the least reimbursement. The mean hospital costs were 3,411 USD for patients insured by NCMS, and those costs were lower than costs incurred by patients insured by some other type of insurance (18,053 USD), UEBMI (8,784 USD), or URBMI (6,071 USD). In Shanghai, the 4 types of insurance schemes varied widely in terms of their financing and reimbursement. Patients insured by supplementary insurance had the highest medical coverage, followed by those insured by UEBMI and NCMS (22). Municipal hospitals were 0.55 times more costly than district hospitals and 7.13 times more costly than primary care facilities, which means that a stay in a primary care facility costs much less than a stay in a hospital.

3.2. *Regression models*

The regression model was statistically significant (F = 865.35, $p < 0.05$), and the estimated coefficients (*i.e*., the variance explained by those variables) of the explanatory variables indicated that 22.82% of the variance in hospital costs could be explained by gender (β = 0.0320, $p < 0.05$), cause of death (Cancer *vs*. other cause, β = -0.9010; Circulatory *vs*. other cause, β = 0.0326; Respiratory *vs*. other cause, β = 0.0730, $p < 0.05$ for all), time-to-death (β = -0.0183, $p < 0.05$), type of insurance scheme (UEBMI *vs*. NCMS, β = 0.3116; URBMI *vs*. NCMS, β = 0.2612; Other type *vs*. NCMS, β = 0.7536, $p < 0.05$ for all), the level of medical facility (Municipal hospital *vs*. Primary care facility, β = 1.2956; District hospital *vs*. Primary care facility, β = 1.1707, $p < 0.05$ for both), and LOS (β = 0.0100, $p < 0.05$), as shown in Table 4.

After controlling for other factors, regression analysis indicated that age was not significantly associated with hospital costs. The current study noted a PTD phenomenon since time-to-death was a significant factor influencing end-of-life hospital costs. For each individual, per capita hospitalization is not necessarily affected by the aging of the population due to an increase in life expectancy. Rather, the increased proportion of the elderly population resulted in more admissions of older individuals, leaving per capita cost unchanged (*10*). Rolden, van Bodegom, and Westendorp created an economic model of hospital cost based on patients' age and time-to-death to predict hospital expenditures from 2002 to 2026 in England, and their results indicated that the predicted annual increase was half of the rate predicted with a traditional method (*19*), indicating that a more accurate projection model should consider the concentration of cost towards the end of life (*23*). At the population level, the increase in life expectancy suggests a larger elderly population, which poses a great challenge to healthcare financing. In order to ensure the sustainability of healthcare financing, excessive medical cost at the end of life should be rationally curtailed.

The type of medical insurance is an important factor that affects the medical care received and its cost (*24-28*). Patients who had supplementary hospital insurance incurred significantly higher healthcare expenditures in Switzerland (*10,13,18*). The current results indicated that insurance schemes significantly influence the end-of-life hospital costs. Individuals insured by NCMS had a significantly lower median rate of admission compared to individuals insured by other types of insurance. The difference in end-of-life hospitalization among types of insurance suggests that individuals with better coverage might receive far more care than individuals with poorer coverage.

Regression analysis indicated that higher levels of medical facilities were most costly. Improving the resources of primary care facilities is one way to meet the needs of terminal patients and to curtail total medical cost. However, the limited number of beds at primary care facilities (17, 099 beds, accounting for 13.92% of total beds) (*29*) and prolonged LOS mean that admission to a primary care facility is unlikely.

Patients with cancer incurred the greatest costs and patients with gastrointestinal diseases incurred the least. The increased cost of cancer treatment has placed a heavy burden on patients and families (*30*). Cancer was the leading cause of death in Shanghai, so the government needs to pay special attention to avoiding financial risks and clinicians need to perform a cost-effectiveness analysis.

The current study had several limitations. It only included decedents who died in medical facilities while a large proportion of individuals who died (over 60%) at home or somewhere else. This may have limited the generalizability of the current findings.

In conclusion, this study found that PTD exists in Shanghai since time-to-death was a significant factor for end-of-life hospital costs. In addition, hospital costs were correlated with gender, cause of death (cancer, circulatory disease, or respiratory disease), time-to-death, insurance scheme, the level of medical facility, and LOS ($p < 0.05$, for all). When the aforementioned factors were controlled for, age was not related to end-of-life cost. This study has suggested that PTD should be considered when predicting medical cost to make the model more accurate. Primary medical care should be enhanced and gaps in insurance coverage should be reduced to improve the efficiency and equity of medical funding. More attention should be paid to the population with a heavier disease burden.

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