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Estimating Economic Burden of Cancer Deaths Attributable to Smoking in Iran in 2012

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ABSTRACT

Background: There is a broad consensus among health policy-makers that smoking has a significant impact on both heath system and society. The purpose of this study was to estimate the economic burden of major cancer deaths caused by smoking in Iran in 2012.

Methods: Number of major cancer deaths due to smoking by sex and age groups in 2012 was obtained from GLOBCAN database. The life expectancy and retirement age were used to estimate years of potential life lost (YPLL) and cost of productive lost attributable to smoking, respectively. Data on prevalence of smoking, relative risk of smoking, life expectancy table, annual wage and employment rate were extracted from the various resources such as previous studies, WHO database and Iranian statistic centers. The data analysis was conducted by Excel software.

Results: Smoking was responsible for 4,623 cancer deaths, 80808 YPLL and $US 83,019,583 cost of productivity lost. Lung cancer accounts for largest proportion of total cancer deaths, YPLL and cost of productivity lost attributable to smoking. Males account for 86.6% of cancer deaths, 82.6% of YPLL and 85.3% of cost of productivity lost caused by smoking.

Conclusions: Smoking places a high economic burden on health system and society as a whole. In addition, if no one had been smokers in Iran, approximately two out of ten cancer deaths could be prevented.

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Introduction

Smoking is one of the most important public health problems throughout the world and is responsible for increasing prevalence of various diseases such as cancers and the increasing of total number of deaths resulting from these diseses[1,2]. For this reason, smoking imposes a significant economic burden on health system and society as a whole. In addition, about 4% of disability-adjusted life years (DALYs) in developed and 13% in developing countries are attributable to smoking, respectively[2,3].

Cancer is most closely related to smoking. Annually, nearby 7 million deaths from cancer occur throughout the world that 21% of them are attributable to smoking[4]. In Iran, cancer is the third leading cause of deaths followed by ischemic heart diseases and road traffic crashes[5,6]. An estimated the number of deaths caused by cancer in Iran will increase from 53,350 cases in 2012 to 58,087 cases in 2015[7]. The prevalence of smoking among male and female adults Iranian (15-64 years) was 26.6 and 4.2%, respectively[8]. One of the main ways to demonstrating the burden of smoking-related cancer is quantifying the burden of them. There are many measures to estimate the burden of cancers: years of potential life lost (YPLL), cost of productivity lost (CPL) and mortality rate[9,10]. The first two are more popular and in the current study, three measures were used.

Most of previous studies about estimating the economic burden of major cancers due to smoking have been conducted in developed countries and the evidence on this field in developing countries less documented[11-13]. Overall, 32.9% cancer deaths among adult men and 5.2% among adult women in 2009 in Korea were attributable to smoking, besides, three in ten cancer deaths could have been prevented if no males and females had smoked in Korea[13]. Quantifying the burden of major cancers due to smoking is very important in order to the better resource allocation for designing and implementing of program aimed at decreasing the prevalence of smoking.

Therefore, the current study aimed to estimate the economic burden of smoking-attributable cancer deaths in Iran in 2012.

Methods

Based on the previous studies[1,2,13] and WHO report[14], the following major cancers due to smoking based on ICD-10 were included in the study: Cancer of the Lip, oral cavity,

pharynx (C00-C09); Esophagus (C15); Stomach (C16); Liver (C22); Pancreas (C25); Larynx (C32) Trachea, lung, bronchus cancer (C33-C34); Cervix uteri (C53); Kidney and other urinary (C64); Bladder (C67) and Colorectum (C18-C20) cancer. The Iranian population aged 35 yr and older was chosen as the study population, because it is believed that the latent period between initial exposure smoking and occurrence cancer are about 20 years and more[15].

Smoking status was classified into three groups: current smoker, former smoker and never smoker. The following formula, proposed by Levin, was used to calculate the smoking attributable fraction (SAF)[16]:

$$SAF(\%)=\frac{[P_n+P_c*RR_c+P_f*RR_f]-1}{[P_n+P_c*RR_c+P_f*RR_f]}*100 \qquad \text{Equation (1)}$$

Where P_n is the prevalence of never smokers; P_c is the prevalence of current smokers; P_f is the prevalence of former smokers; RR_c denotes the RR of current smokers compared to never smokers and RR_f denotes the RR of former smokers compared to never smokers.

Data on prevalence of various status of smoking was obtained from the national study on Chronic Disease Risk Factor Surveillance among individual 15-65 years[8] and 65 yr and above[17]. Age groups were categorized into two groups: ages 35-64 and ages 65+ yr. Because the data about RR of smoking for selected cancer in the study for Iranian population was not available, so the relative risks of smoking were obtained from the study conducted in the Korea in 2014[13]. Data on numbers of smoking-attributable cancer deaths by sex and age groups including 35-64 and 65+ yr were obtained from the GLOBOCAN databases[18].

The 2012 Iran life table was extracted from WHO database and used in order to calculate the average of life expectancy for each age group[19]. Data on age-and gender-specific wages, employment and housekeeping rate were extracted from the Iranian Ministry of Cooperation Labor and Social Welfare (IMCLSW) and the Iranian Statistical Center (ISC), respectively[20, 21]. In addition, the data about household activity of the female was not available, so the minimum daily wage approved by IMCLSW was used for the female household activities.

Calculation of YPLL for smoking-attributable cancer

YPLL for cancer due to smoking was estimated as follows: first, we assumed that all of deaths in each age group occurred in the mid-point of that age group. Therefore, to calculate of YPLL, the number of deaths in each group was multiplied by the average of remaining life expectancy. Second, based on the following formula, the YPLL of cancers attributable to smoking was computed:

Smoking-attributable YPLL= total YPLL of each cancer × SAF

YPLL and smoking-attributable YPLL were calculated by cancer, sex and age groups (35-64 and 65 yr and over). Besides, to estimate the average YPLL per cancer deaths caused by smoking, the quantity of YPLL was divided by the cases of smoking-attributable deaths.

Calculation of cost of productivity lost (CPL)) for smoking-attributable cancer

To estimate the cost of productivity lost (or indirect cost), as similar to the previous studies[22, 23], the human capital approach was employed. The CPL was estimated as follows: first, the YPLL according to the previous section was estimated, only in terms of CPL, we disregarded any deaths beyond 65 yr, thereby assuming all of those working will retire at 65 yr. Then, the estimated YPLL was multiplied by age and sex-specific annual wages from age of deaths until the retirement age. The estimated CPL was adjusted based on the employment and housekeeping rate. In addition, to obtain the present value the future costs were discounted at 3% per year. CPL for each death was summed across age groups by sex and cancer site.

Second, to estimate the cost of productivity lost attributable to smoking (CPLAS), the following formula was used:

CPLAS= total cost of productivity lost for each cancer × SAF

The cost of productivity lost per YPLL and death attributable to smoking were also estimated, thereby the estimated average CPL per YPLL and death was divided the average of YPLL and deaths, respectively. All the costs were converted to US dollars (US $) using the average annual 2012 exchange rate (US$1=Rial 12,290)[24]. In addition, the data analysis was done by Excel software.

Results

Based on GLOBOCAN 2012 report, 53,350 deaths due to cancer occurred in Iran in 2012 which 28,387 (17841 male vs. 10526 female) of them were related to major cancer associated with the smoking. In male, aged 35-64 yr, 54.7% of lung cancer deaths, 55% of larynx and 43% of lip, oral cavity and in male with aged 65 yr and over about 42% of lung cancer deaths, 41% of larynx, 26% of esophagus was attributable to smoking. 20.3% and 9.6% of lung cancer deaths were attributable to smoking among female with age of 35-64 and 65 years and above, respectively (Table 1).

Table 1: Major cancer deaths due to smoking by cancer site, sex and age groups; Iran 2012

	All deaths				Number of Cancer deaths attributable to smoking							
					35-64				≥65			
	35-64		≥65		Male		Female		Male		Female	
Cancer site	Male	Female	Male	Female	Deaths	SAF%	Deaths	SAF%	Deaths	SAF%	Deaths	SAF%
Stomach	1556	915	4061	1606	287	18.5	47	5.1	594	14.6	3	0.2
Esophagus	941	978	1683	1243	348	37.0	84	8.6	450	26.8	32	2.6
Colorectal	951	1044	1217	858	38	4.0	64	6.1	48	3.9	7	0.8
Lung	1095	615	1819	739	599	54.7	125	20.3	767	42.1	71	9.6
Liver	304	221	506	393	40	13.1	40	18.0	51	10.1	32	8.2
Bladder	441	99	1376	351	124	28.2	8	7.9	270	19.7	5	1.3
Kidney	274	190	305	179	9	3.2	30	15.8	5	1.5	13	7.2
Larynx	236	30	235	45	130	55.2	5	16.4	98	41.6	3	6.4
Pancreas	238	221	364	256	36	15.0	10	4.6	34	9.5	1	0.2
Lip oral cavity	101	79	138	106	43	43.0	11	14.6	32	23.0	5	5.2
Cervix uteri	-	207	-	151	-	-	21	10.3	-	-	5	3.1
Total	**6137**	**4599**	**11704**	**5927**	**1654**		**445**		**2348**		**176**	

SAF%: smoking attributable fraction

Smoking was responsible for 4002 (22.4%) and 621 (5.9%) of all cancer deaths among adult males and females (35 yr and over), respectively. In addition, the largest proportion of total deaths attributable to smoking belonged to lung cancer; approximately at 34.1% (in males) and 31.5% (females) of total, respectively (Figure 1).

Total YPLL and YPLL per death attributable to smoking by cancer site, sex and age groups are shown in Table 2. There were 471,697 YPLL due to deaths from major cancer associated with smoking which 17.2% (80808) of them were attributable to smoking. In addition, of total YPLL attributable to smoking, 82.7% (66800) belonged to the males. The leading cause of YPLL and smoking-attributable YPLL in males and females were stomach and lung cancers, respectively. The YPLL per death ranking attributable to smoking were different from their rankings according to the smoking- attributable YPLL. For example, lung cancer in males ranked 1st in terms of smoking- attributable YPLL and ranked 5th in terms of YPLL per death. The highest YPLL per death caused by smoking in males and females was lip, oral cavity cancer, respectively (Table 2).

Table 2: Years of potential life lost (YPLL) and YPLL per death caused by smoking by cancer site, sex and age groups; Iran 2012

	YPLL				YPLL and YPLL per death attributable to smoking							
					35-64				≥65			
	35-64		≥65		Male		Female		Male		Female	
Cancer site	Male	Female	Male	Female	YPLL	YPLL/ death	YPLL	YPLL/ death	YPLL	YPLL/ death	YPLL	YPLL/ death
Stomach	38774	24009	43026	17776	7173	25.0	1224	26.1	6282	10.6	28	9.5
Oesophagus	23609	25342	18120	14156	8735	25.1	2179	25.9	4856	10.8	367	11.5
Colorectum	25494	29574	13197	9905	1020	26.8	1804	28.2	515	10.7	75	10.8
Lung	27643	16809	19566	8344	15121	25.2	3412	27.3	8237	10.7	798	11.2
Liver	7785	5891	5493	4248	1020	25.5	1060	26.5	555	10.9	347	10.8
Bladder	10787	6073	14352	2871	3042	24.5	191	23.9	2827	10.5	48	9.7
Kidney	7065	2416	3372	3695	226	25.1	827	27.6	51	10.1	149	11.4
Larynx	5948	5236	2628	2064	3283	25.3	111	22.2	1093	11.2	31	10.3
Pancreas	5746	676	4071	488	862	23.9	279	27.9	387	11.4	6	6.0
Lip oral cavity	2739	2298	1467	1169	1178	27.4	336	30.5	337	10.5	61	12.1
Cervix uteri	-	6016	-	1759	-	-	620	29.5	-	-	55	11.0
Total	**155590**	**124340**	**125292**	**66475**	**41660**	**-**	**12043**		**25140**		**1965**	

In males, lung and esophagus cancers were responsible for 30.1% and 18.2% of smoking-attributable total YPLL, respectively; while in females, it was 35% and 20.3% of total, respectively. The proportion of smoking-attributable YPLL by cancer site and sex is shown in Figure 2.

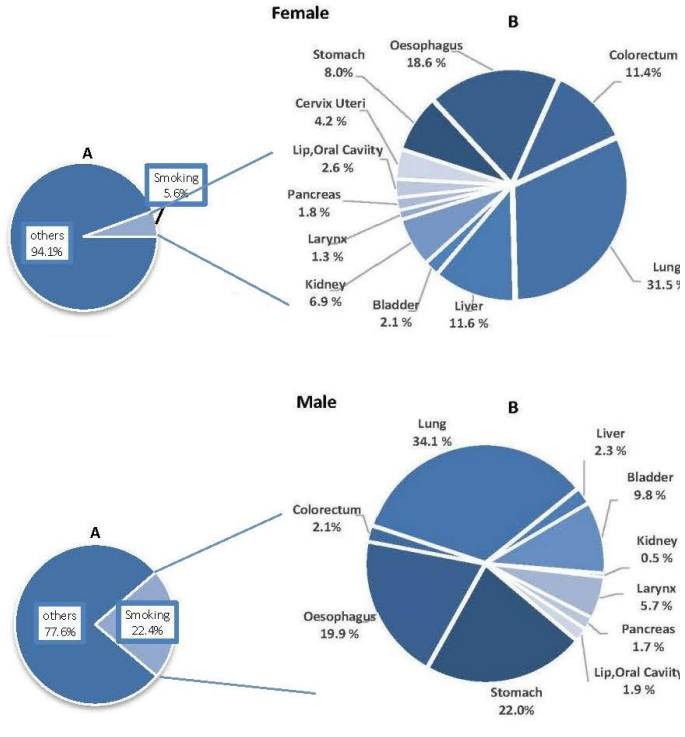

Figure 1: percentage of cancer deaths attributable to smoking in Iranian male and female; 2012
A: proportion of total cancer deaths caused by smoking; **B:** Proportion of smoking-attributable deaths by cancer site

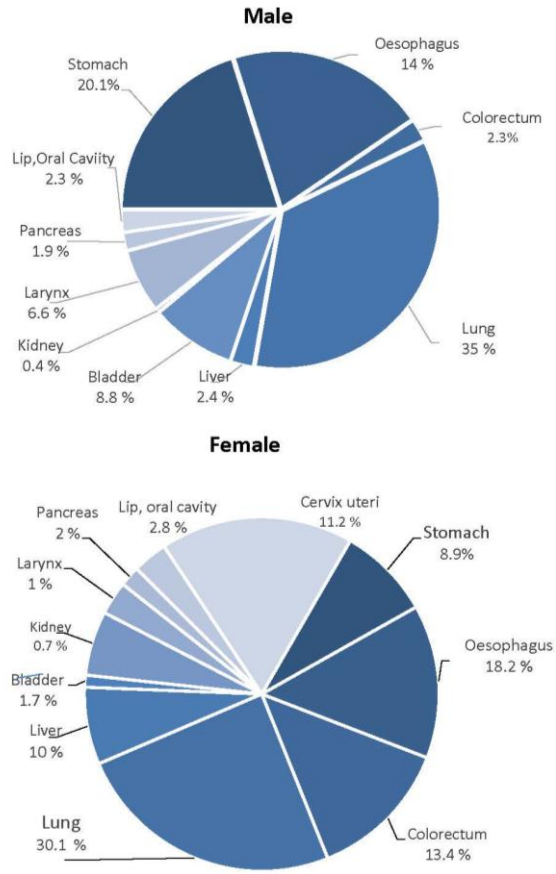

Figure 2: Proportion of YPLL from cancers deaths attributable to smoking by cancer site and sex; Iran 2012

Total CPL by major cancer associated with smoking was $US 393,945,909, which 68.7% (270,898,835) of them were in the males. In addition, the total CPLAS was $US 83,019,583, which about 85.3% (70,807,382) of them were for males. Regarding males, the highest CPL per YPLL and per death attributable to smoking were lip, oral cavity cancer; while in females, it was cervix uteri. The CPL per YPLL and per death ranking attributable to smoking were different from their rankings according to the CPLAS. For example, lung cancer in the males ranked 1st in terms of smoking-attributable CPL and ranked 6th in terms of CPL per YPLL and per death (Table 3). The proportion of CPLAS by cancer site and sex are shown in Figure 3. Considering males and female, 26.1% and 3% of total CPL were attributable to smoking, respectively. Lung cancer accounts for 36.4% and 24.6% of total CPLAS among males and female, respectively.

Table 3: Cost of productivity lost (CPL) results of major cancer due to smoking by cancer site and sex in Iran, 2012, (US $)

	CPL [a]		CPL, CPL per death and per YPLL attributable to smoking					
			CPLAS [b]		CPL/YPLL		CPL/death	
Cancer site	Male	Female	Male	Female	Male	Female	Male	Female
Stomach	64,576,101	20,336,868	11,946,579	1,037,180	1,665	847	41626	22,068
Esophagus	40,012,461	19,933,554	14,804,611	1,714,286	1,695	787	42542	20,408
Colorectal	50,976,694	26,142,884	2,039,068	1,594,716	1,999	884	53660	24,917
Lung	47,129,853	14,818,927	25,780,029	3,008,242	1,705	882	43038	24,066
Liver	14,016,960	4,788,384	1,836,222	861,909	1,800	813	45906	21,548
Bladder	17,155,688	1,700,452	4,837,904	134,336	1,590	703	39015	16,792
Kidney	12,873,051	4,548,391	411,938	718,646	1,823	869	45771	23,955
Larynx	9,921,178	2,273,846	5,476,490	372,911	1,668	3,360	42127	74,582
Pancreas	8,740,369	4,925,553	1,311,055	226,575	1,521	812	36418	22,658
Lip oral cavity	5,496,480	2,670,796	2,363,487	389,936	2,006	1,161	54965	35,449
Cervix uteri	-	20,907,421	-	2,153,464	-	3,473	-	102,546
Total	**270,898,835**	**123,047,074**	**70,807,382**	**12,212,201**	-	-	-	-

[a] Cost of productivity lost discounted at 3%
[b] Cost of productivity lost attributable to smoking

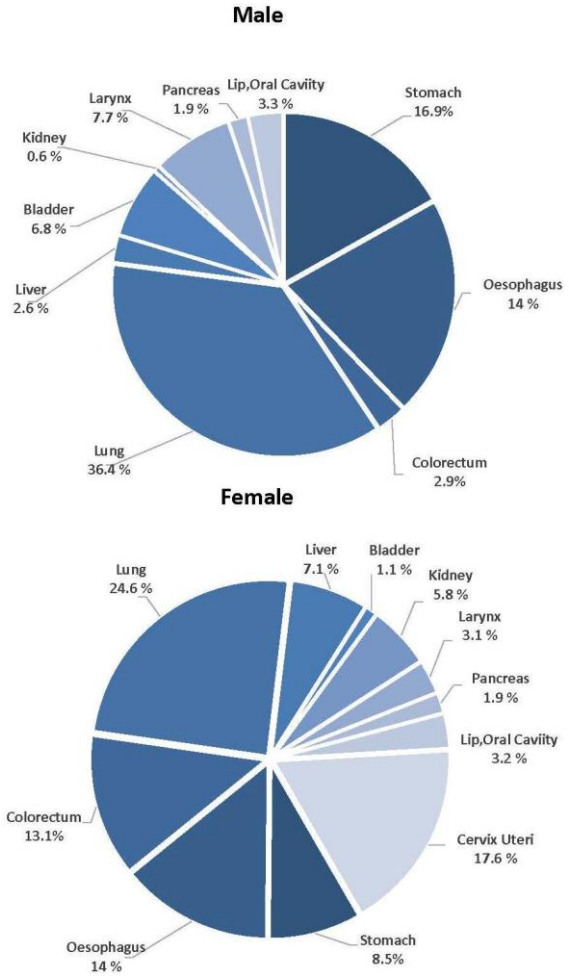

Figure 3: proportion of cost of productivity lost attributable to smoking by cancer site among individual with 35-64 years; Iran 2012

Discussion

The study aimed to estimate the economic burden of cancer- attributable deaths due to smoking in Iran for the year 2012. Overall, among 28,387 cancer deaths in Iran adult (35 yr and above) in 2012, 4,623 (16.3%) were attributable to smoking. The current study indicated that there was a high difference between males and females in the deaths caused by smoking. Of total deaths attributable to smoking, 4002 (86.5%) and 621 (13.5%) were in males and females, respectively. In addition, 22.4% and 5.9% of cancer-related total deaths among males and females were attributable to smoking. This finding implies approximately two in ten cancer deaths among Iranian population aged 35 yr and above could have been prevented if there had been no smokers. Park et al.[13] concluded three in ten cancer deaths could have been prevented if no males and females had smoked in Korea. Besides, the smoking was responsible for 32.9% cancer deaths among adult men and 5.2% cancer deaths among adult women in 2009 in Korea that is higher than our finding. This can be explained by the fact that the Korea population aged 20 yr and over were considered as the study population, while in our study it was 35 yr and over. In addition, the prevalence of smoking among Iranian adults population was less than in comparison to Korean adult's population.

Our analysis showed that smoking was responsible for 17.2% (80808) of total YPLL of cancer deaths and of total YPLL attributable to smoking, 82.7% (66800) belonged to the males. In the United Kingdom in 2009, smoking was responsible for 12.1% of total DALYs[25]. The ranking of cancer by YPLL and YPLL per deaths attributable to smoking was different. Among males, for example, lung cancer ranked 1st in terms of smoking- attributable YPLL and ranked 5th in terms of smoking- attributable YPLL per death. In both sexes, among the major smoking-attributable cancers, lung, Lip, and oral cavity cancers were highest in terms of YPLL and YPLL per deaths, respectively. In addition, this study indicated that lung cancer accounts for 35 and 30.1% of smoking-attributable total YPLL in the males and females, respectively. Oh et al. in Korea[2] have reported the highest

YLL and DALY among the major smoking-related cancer deaths in 2008 as lung cancer, which is consistence with our study.

The current study indicates that the estimated total CPL was $US 393,945,909 which 22% of them are attributable to smoking. In both sexes, lung cancer was the most costly cancer in terms of cost of productivity lost caused by smoking and accounts for 36.4% and 24.6% of smoking-attributable total cost of productivity lost among males and females, respectively. Total CPLAS for males and females was $ US 70,807,382 and 12,212,201, respectively which for males was 5.8 times higher than to females. This difference is that the higher prevalence of smoking (26.6 vs. 4.2%) and higher employment rate (68% vs. 9%) as well as higher annual wage ($US 12104.3 vs. $US 10193) were among males compared to females. Oh et al.[2] estimated the total indirect cost of major cancer due to smoking as $ US 2,271 million in Korea in 2008 which 73% of them accounted for males.

In the current study, as similar to the previous studies[9,22,23,26], the human capital approach was used to estimates CPLAS. Our estimate showed the total CPLAS was $US 83,019,583 which accounts for 0.015% of the Iran gross domestic production (GDP; US$ 551.6 billion) in 2012. Oh et al.[2] estimated the economic cost (direct and indirect costs) of major cancer attributable to smoking in Korea for the year of 2008. It is estimated that these costs were $US 3,140 million which accounted for 0.33% of Korea's GDP. Their result is different from our estimate, because in their study both indirect and direct costs were computed, while in our study only indirect cost was calculated. In addition, it may be due to the lower employment rate, lower prevalence of smoking as well as lower annual wage among adults Iranian compared to adults Korean.

The present study has several limitations and its results should be interpreted in line of these limitations. First, the relative risk of smoking for cancers in Iran is not available and the relative risk were obtained from the previous studies which may not correctly represent the Iranian situation. Second, the human capital approach was adopted to estimate the CPL. In this method, the earning market was used to calculate the value of human life and then, the older age and females were assigned as a lower value. Therefore, the actual CPL may be different from the actual cost.

Conclusions

To our acknowledge, this is the first attempt at national level to estimate the economic burden of major cancer due to smoking in Iran. Our finding implies that the economic burden of smoking-caused cancer deaths in Iran is substantial. On the other words, smoking was responsible for 16.5% of cancer deaths, 17.2% of YPLL and 21% of cost of productivity. Besides, the largest proportion of cancer deaths, YPLL and cost of productivity lost attributable to smoking was related to lung cancer. Two out of ten cancer deaths could be saved if there had been not smokers in Iran. To reducing the burden of smoking, the effective program to decrease prevalence of smoking such as raising taxes on cigarette should be further designed and implemented in Iran.

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Conflict of interest statement

Authors declared that they have no conflict of interest.

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