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Household Perceptions about Drinking Water Quality and Human Health: A Comparative Analysis of Urban and Rural Areas in Pakistan

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ABSTRACT

Public awareness about safe drinking water plays a significant role in household choices for drinking water sources and the prevention measures of water contamination. The present study was aimed to explore the awareness of households about groundwater quality and investigate the incidence of waterborne diseases in comparison with urban and rural households. Primary data were collected from 600 households by using stratified random sampling technique. To analyze the outcomes descriptive and graphical approaches were used, however, to check the association between water sources and waterborne diseases bi-variate techniques were employed. It was found that the households belonging to urban localities were more aware about health risks associated with drinking water quality. Outcomes disclosed that on average 48.8% of the households get affected by drinking water quality and face waterborne diseases, however, the incidence was greater (49.7%) in rural households compared to (48.0%) urban households. Findings also revealed that on average 58.8% of the households suffered from belly pain and stomach problems and its incidence was 60.4% and 57.4% in rural and urban areas, respectively. Results disclosed that household income and medical expenditures were significantly associated with drinking water facilities. It is suggested that awareness about water quality should be disseminated among households to reduce the incidence of waterborne diseases.

Key Words: Drinking water, awareness, water source, health, waterborne diseases, medical expenditures

1. INTRODUCTION

Water is an important resource on earth for life (Motoshita et al., 2011). People need water and sanitation to sustain life and maintain their health. Fresh drinking water is

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an important determinant of human health (Adamou et al., 2020). Lack of safe drinking water can create a heavy cost burden on nations' economies and hinders the smooth growth process (WHO, 2017).

Availability of clean drinking water is one of the major concerns all over the world. Drinking water quality is badly affected due to industrialization, high population growth, excessive use of chemicals in agriculture and the leakages of water reservoirs and pipelines are the main causes of water pollution (Haseena et al., 2017). Human activities have steered to a wide range of chemical, pharmaceutical, biological and physical pollutants in freshwater resources that are adversely affecting human health (Gao et al., 2020; Wang et al., 2020; Menendez et al., 2019; Patel et al., 2019). Water quality is also influenced by the source of water, duration of water storage and place, and the distance to the water source (Boateng et al., 2013).

Contamination in drinking water poses a serious threat to public health (Dantas et al., 2020; Hu et al., 2020; Ravindra and Mor, 2019). As the use of unsafe or contaminated drinking water cause many public health issues, such as diarrhoea, cholera, and hepatitis, etc. (Fotue, 2013). It is estimated that more than one billion people in the world have no access to clean or uncontaminated water and have inadequate sanitation facilities. A large number of people in developing countries suffer from different health problems due to lack of drinking water and the presence of microbiological contamination in water (Zulfiqar et al., 2016). It is estimated that in developing countries about 14,000 deaths occur per day due to water contamination as a result of untreated sewage (Owa, 2013). Around 60% of infant deaths and 20 to 30 percent of hospital cases belong to waterborne diseases. It is estimated that every year 230,000 children die in Pakistan due to waterborne diseases (Rehman and Baig, 2017).

The importance of water is not only because of accessible and adequate supply but also of water quality (Sousa et al., 2015). Access to clean drinking water has become a major issue at the national and regional level as a matter of health and development (Wang et al., 2018). The use of safe drinking water can contribute to a healthy life (Bowyer et al., 2020). World health organization narrated that the improvement in the supply of potable water to the households can reduce diarrheal diseases up to 25 %

(WHO, 2008). However, the individual's attribute matters a lot in the decision-making process. Public awareness regarding drinking water quality plays an important role in drinking water source choice and disease prevention measures of households (Wright et al., 2012). Perception is a major influencing factor of a person's awareness level and changes because of personal, social, and economic factors (Chatterjee et al., 2017). Households having awareness about water contamination and associated health risks, invest in prevention measures. Thus, public awareness about drinking water quality cannot be sacked (Means, 2002; Mahler et al., 2015).

The present study aimed to address the following objectives: 1) To check the awareness level of households about water quality, 2) To compare the sources of drinking water and incidence of waterborne diseases in urban and rural households, 3) To investigate the association between the drinking water facility and medical expenditures of households.

The remaining part of the paper is organized as follows; section 2 covers the brief review of the literature, part 3 comprises the materials and methods used in the study, whereas, section 4 covers the results and discussion. However, the last section covers the conclusions of the study.

2. LITERATURE REVIEW

Access to safe water and sanitation significantly improve public health (Agbadi et al., 2019). Chemical and biological constituents in drinking water can be a potential health risk for human health (Luz and Kumpel, 2020). The spread of waterborne diseases and more health burden can be the cause of epidemics (Shahzad et al., 2019). Demographic factors and the age of the household head affect access to improved sources of drinking water (Simelane et al., 2020). Rehman and Baig (2017) found that contaminated water caused many water-borne diseases such as Diarrhea, Dysentery, and Typhoid. Khalid et al. (2018) also found that water-borne diseases spread due to microbial contamination and causing a serious threat to human health. An association was found between the unimproved or poor supply of water and infant diarrheal disease (Geere and Hunter, 2020).

Public perception regarding the opportunity cost of consuming unsafe drinking water affects highly due to education and the level of awareness (Haq et al., 2007). Awareness relates positively to the adoption of improved water source choices. It was found that the more educated households head has more probability to choose the improved water sources than the illiterate household heads (Fotue, 2013; Tussupova et al., 2015). According to Jabeen et al. (2011), lack of awareness remained the major reason for poor health. Jalan et al. (2009) found that educational attainment and mass media considerably affect the demand for safe drinking water, as well as willingness to pay. They concluded that awareness and schooling increase the demand for environmental quality. They suggested that awareness regarding health risks associated with poor environmental quality should be given through schooling and media. Nabeela et al. (2014) explored water pollution as one of the serious problems for human health. They argued that municipal waste, industrial disposal, poor sanitary conditions and lack of filtration, and poor water supply system were the major causes of drinking water contamination.

According to Akpan and Ajayi (2016) deposit of sewage into the natural sources of water had been a major contributing factor to water contamination. However, contaminated water weakens the health as well as an individual's living. Labrador et al. (2020) also argued that pathogens and faecal contamination through the environment cause a serious health risk. According to Pasha et al. (2020) water can be polluted due to various factors, as leaking tanks, untreated sewage and drain storms. Thus to reduce the health risk, economic and environmental losses, precise detection of contaminants was needed. Geere and Hunter, (2020) concluded that fetching of water was associated with child and maternal health. Rahman et al. (2020) found that the association between awareness, water and health helps to minimize the health risks. Wang et al. (2018) found that the respondents with higher levels of education had greater awareness than the respondents with lower levels of education about water contamination as well as quality. The increased access through public tube wells was common but inadequate to reduce the risks of drinking water (Hoque et al., 2019). Islam et al. (2020) also found the link between water salinity and the risk of infectious disease as well as health issues.

Kausar et al. (2011) investigated the factors that influence water quality and household health in Punjab, Pakistan. They found that the socio-economic structure was one of the main risk factors for diarrheal diseases. They concluded that there was a significant relationship between the mother's education, household income, family type, and health risk. However, the families who used better quality drinking water and adopted remedial measures for safe quality water were at less diarrheal risk than others. Water supply connections to houses revealed a high correlation with infectious diseases and water scarcity strongly linked with health damages (Motoshita et al., 2011). Ali and Akhtar (2015) found that the majority of the respondents knew about water-borne diseases. However, there was a significant association between the education and income of the respondents and the incidence of waterborne disease. Akhtar et al. (2005) found that income and education of the respondents had a significant positive association with awareness regarding water pollution. They suggested that the media should play a positive role to inform or aware people regarding water pollution. According to Gomez et al. (2019) in middle-income countries, socio-economic factors significantly affect the access to water resources in rural areas. Urban water services enhance the sustainability, liveability and productivity of the cities (Rogers et al., 2020).

2.1. Hypothesis

H₁: *Households of urban localities are more aware regarding water quality issues than rural households*

H₂: *There is a relationship between the income of household and drinking water facility.*

H₃: *Drinking water sources are influenced by the residential locality of the households.*

3. RESEARCH METHODOLOGY

3.1. Site Characteristics

The area selected for study purposes was the localities of Faisalabad, Pakistan. Faisalabad is the second most populated and main industrial city of Punjab, Pakistan. The area of the Faisalabad district is 5856 Km² with the inhabitants of 1.23 million households according to the 6th population census. Faisalabad has become a main industrial hub and distribution centre due to its central location in the region. However,

due to industrialization and rapid population growth, Faisalabad has been facing serious problems related to drinking water which causes a serious impact on human health. Faisalabad is producing 4.09 m³/s industrial and domestic discharges (Yamin et al., 2015) due to which the quality of drinking water is being adversely affected. Keeping in view the rising issues related to water present study choose the households of Faisalabad as the targeted population.

3.2. Sampling and Collection of the Data

Faisalabad district is composed of eight autonomous towns, namely; Iqbal town, Madina town, Lyallpur town, Jinnah town, Jaranwala town, Chak-Jhumra town, Samundri town, and Tandlianwala town. The present study used a stratified random sampling approach for sampling by distributing the population into urban and rural strata. To determine the appropriate sample size the following formula was used as shown in equation (1).

$$n = \frac{N * X}{(X + N - 1)} \quad (1)$$

Where,

$$X = Z_{\frac{\alpha}{2}} * \frac{P * (1 - p)}{MOE^2} \quad (2)$$

Nevertheless, $Z_{\frac{\alpha}{2}}$ is the critical value for normal distribution at $\alpha/2$, (where α is the confidence interval which was selected 0.05 and critical value is 1.96), MOE is the margin of error (4), p is the sample proportion, N is the population size. However, by selecting confidence level 0.05 and at the margin of error of 4% the sample size was determined to be 600 households.

Subdivision of 600 households was done on the basis of stratified random sampling. Strata were divided on an equivalent basis, such as 300 households from urban and 300 households from rural localities. Furthermore, in rural strata, four strata were identified, as, town Jaranwala, Jhumra, Summundri, and Tandlianwala. From each town total of 75 households were selected, furthermore, from each town five union councils were randomly identified, and from each union council one village was selected and fifteen households from each village were randomly selected. Similarly, in urban

localities, Iqbal town, Jinnah town, Lyallpur town, and Madina town were identified as urban strata and the same procedures were applied in urban localities as applied for the rural.

After that, a data collection procedure has been performed. Data were collected through a well-structured questionnaire comprising questions related to household's socioeconomic characteristics, their drinking water source, and health expenditures due to waterborne diseases. Before the collection of the data, a pretesting practice was carried out to test the validity of the questionnaire. As a result of pretesting some minor changes were made and finalizing the questionnaire, then the data collection process was performed. After data collection, raw data were coded and organized for further processing.

3.3. Data Analysis

Data were analyzed in two steps procedure; in the first step, a quantitative and graphical analysis was carried out and compared the outcomes regarding the residential areas of households, whereas, in the second step bivariate analysis was done. To confirm the bi-variate association between variables, Chi-square and gamma approaches were applied. In a random sample 'n' is the number of observations from a population that are classified into mutually exclusive classes k, with particular observed numbers x_i , where, $i=1, 2, \dots, k$. Thus the expected statistics $m_i=nP_i$, where,

$$\sum_{i=1}^k P_i = 1 \quad (3)$$

$$\sum_{i=1}^k M_i = n \sum_{i=1}^k P_i = \sum_{i=1}^k Z_i \quad (4)$$

Under such conditions Pearson suggested that the null hypothesis being correct as $n \rightarrow \infty$ restraining size of distribution is the χ^2 distribution as;

$$\chi^2 = \sum_{i=1}^k \frac{x_i^2}{m_i} - n \quad (5)$$

3.4. Conceptualization of the Subject Matter

Some important terms used in the study were residential area, drinking water sources, water facility, and waterborne diseases. In this study residential status was operationalized in two categories, as urban and rural areas. Drinking water sources were

categorized into domestic groundwater, piped water supply, public tap, water vendors, filtration plant, and bottled water. Respondents were also inquired about their perceptions about drinking water facilities. Furthermore, the study also incorporated the medical expenses of households due to the intake of poor quality water. Households were asked how much rupees/month they spend for the treatment of water-related diseases openly, after the collection of data expenditures were transformed into different categories keeping in view the trends of data. However, these expenses were categorized as Rs. <300, 301-600, 601-1000, 1001-1500 and >1500 PKR per month.

4. RESULTS AND DISCUSSION

Table 1 showed the households' awareness level regarding health issues due to intake of poor quality of water, results have been presented in the form of percentages and frequencies. The overall results showed that out of the total sample 93.7% of the households were fully aware of the health risks associated with poor quality of drinking water. On the other hand, the households who were not aware or somewhat aware were 3.5% and 2.8%, respectively. The segregate findings for rural and urban areas indicated that the awareness level was greater for households who lived in urban areas (97.7%) as compared to the rural areas (89.7%), these outcomes are in favor of alternative hypotheses (Ho: rejecting the null hypothesis). However, the incidence of not being aware and somehow aware was greater in rural than urban households

Table 1. Distribution of Households regarding Awareness Level about Health Risk due to Poor Quality Drinking Water

Awareness	Area		Average percent (Total counts)
	Rural Percent(Counts)	Urban Percent (Counts)	
Fully aware	89.7% (269)	97.7% (293)	93.7% (562)
Not aware	5.3% (16)	1.7% (5)	3.5% (21)
Somewhat aware	5.0% (15)	0.6% (2)	2.8% (17)
Total	100.0% (300)	100.0% (300)	100.0% (600)

Awareness of the respondents leads towards the right direction to know the object in more detail and helps to recognize the issues related to a particular facility or area. Table 2 illustrated that out of the total rural households 81.0% were of the view that

they had a problem with their domestic groundwater, whereas, 14.3% responded that they had no problem and 4.7% households responded moderately and were not sure about the problem with their water quality. On the other hand, in urban areas 83.6% of households' opinion that they had problems with their domestic groundwater, however, the households who stated that they had no problem or responded moderately were 13.7% and 2.7%, respectively. Results showed that groundwater quality problems were greater in urban areas than in rural areas. Overall, outcomes revealed that most of the respondents (82.3%) were aware of the problems with their domestic groundwater quality.

Table 2. Perception of Respondents about the Problem with their Groundwater Quality

Problem with ground water	Area		Average percent (Total counts)
	Rural Percent (Counts)	Urban Percent (Counts)	
Yes	81.0% (243)	83.6% (251)	82.3% (494)
No	14.3% (43)	13.7% (41)	14.0% (84)
Don't know/moderate	4.7% (14)	2.7% (8)	3.7% (22)
Total	100.0% (300)	100.0% (300)	100.0% (600)

Many factors influence the household's awareness regarding water quality, such as, the human sensual insight of color, odor, and taste that may detect contamination in water. Table 3 described the household's perceptions regarding the issues with their groundwater. The overall outcomes revealed that most of the respondents (73.5%) had taste concerns and stated that the taste of their groundwater is not good. Other than taste 12.8% and 3.0% of the total respondents face smell and color issues, respectively. Likewise, 10.7% of the total respondents were of the view that they had more than one issue with their groundwater, like the taste, smell, and color. Findings also disclosed that issues related to taste and color of water were more in rural than urban, whereas, the incidence of more than one problem was greater in urban (17.3%) compared with rural (4.1%).

Table 3.Perception of Households Regarding the Problems of Groundwater Quality

Groundwater quality issue	Area		Average percent (Total counts)
	Rural Percent (Counts)	Urban Percent (Counts)	
Taste	79.2% (194)	67.8% (169)	73.5% (363)
Smell	11.8% (29)	13.7% (34)	12.8% (63)
Color	4.9% (12)	1.2% (3)	3.0% (15)
All/other	4.1% (10)	17.3% (43)	10.7% (53)
Total	100.0% (245)	100.0% (249)	100.0% (494)

Awareness level is greatly associated with the education level of the respondents (Fotue, 2013). Table 4 exhibited the prevalence of education level among the household heads. Results showed that 1.8% of the total households were illiterate, but the incidence of illiteracy was higher in rural households (1.9%) compared with urban households (1.7%). However, a sizable percentage of households were primary (11.4%), Middle (18.3%), Matric (28.2%), Intermediate (15.2%), Graduation (12.8%), and Master (8.3%). On the other hand, only 4.0% of the household heads had M.Phil. or above qualification. Nevertheless, the incidence of higher education was greater in the urban household (Graduation, 16.0%; Masters, 9.3%; M.Phil. and above, 7.0%) compared with the rural household (Graduation, 9.6%; Masters, 7.3 %, M.Phil. and above 1.0%). Conversely, the prevalence of illiteracy and primary was higher in rural households than the urban households, as illiteracy and primary ratio were 1.9% and 16.5% in rural, whereas, 1.7% and 6.3% in urban households, respectively.

Table 4. Prevalence of Education level among the Household's Heads in the Rural and Urban Area

Education level	Area		Average percent (Total counts)
	Rural Percent (Counts)	Urban Percent (Counts)	
Illiterate	1.9%(6)	1.7%(5)	1.8%(11)
Primary	16.5%(48)	6.3%(19)	11.4%(67)
Middle	24.3%(73)	12.3%(37)	18.3%(110)
Matric	30.1%(90)	26.3%(79)	28.2%(169)
Inter.	9.3%(28)	21.1%(63)	15.2%(91)
Graduation	9.6% (30)	16.0%(48)	12.8%(78)
Master	7.3%(22)	9.3%(28)	8.3%(50)
M.Phil. and above	1.0%(3)	7.0%(21)	4.0%(24)
Total	100.0%(300)	100.0% (300)	100%(600)

Clean drinking water is paramount for public health. In Pakistan, drinking water needs are mostly fulfilled from underground aquifers or surface water sources. When households encounter the poor quality of their groundwater, they move towards alternative water sources, such as water supply, public tap, filter plants, water vendors, and bottled water supply for drinking and cooking purposes (Chatterjee et al., 2017). Figure 1 showed the percentage of households regarding their drinking water sources. The graph showed that on average 3.2% of households were relying on domestic groundwater for drinking purposes and most of them belonged to rural areas. On the other hand, on average 9.7% of households were associated with piped water supply, however, 13.0% and 6.3% of the households' belonged to rural and urban areas, respectively. Results indicated that on average a large percentage of households (39.8%) were connected with the public tap, however, its share was greater in rural (50.3%) compared with urban households (29.3%). Dependency on filter water plants also had a sizable percentage (26.7%), nonetheless, its share was greater in urban (42.0%) compared with rural (11.3%) households. Furthermore, on average 12.7% of households purchase water from small-scale water vendors. A small percentage of households 3.8% were linked with bottled water sources and most of them belong to urban areas (7.3%) and usage of bottled water seems negligible (0.3%) in rural areas. Besides this, overall 4.2% of the households were relying on more than one water source.

Figure 1. Comparison of urban and rural households regarding drinking water sources

Different types of drinking water sources used by the household affect them in different manners. Therefore, in this study people were asked about health issues or diseases in their family due to drinking water. Results in Figure 2 disclosed that on average 48.8% of the households get affected by drinking water quality and face waterborne disease, however, the incidence of diseases was greater (49.7%) in rural households compared to (48.0%) urban households. These outcomes are in accordance with the results of Ali and Akhtar (2015), who also found that the majority of the family members of the respondents were affected due to poor quality of drinking water and had health issues. Similarly, Jabeen et al. (2011) also found that the ratio of disease occurrence was high in rural areas as compared to urban areas. Overall 23.7% of the total household responded that they did not suffer from waterborne diseases and 27.5% of the respondents stated that they face waterborne diseases but less frequently, out of which 27.7% and 27.3% belong to rural and urban areas, respectively.

Figure 2. Prevalence of household suffer from diseases due to poor quality of drinking water

Usage of poor quality or contaminated drinking water badly affects human health and causes various diseases, such as Diarrhea, Cholera, Hepatitis, Dysentery, Kidney and Stomach problems. Figure 3 describes the percentage of households who suffer from various waterborne diseases. Results disclosed that a large segment of the households (58.8%) suffered from belly pain and stomach problems, whereas, the incidence was higher in rural (60.4%) than urban (57.4%). These results are in line with the findings of

Jabeen et al. (2011), who also found that belly or stomach problems were the most prevailing and common diseases among people. On the other hand, the percentage of households who suffered from other diseases like Diarrhea, Cholera, Kidney problems, Hepatitis, and Dysentery was 5.8%, 4.3%, 2.4%, 6.5%, and 6.5%, respectively. Furthermore, the households who stated that they suffered from more than one disease were found to be 5.7%.

Figure 3. Prevalence of different disease among households due to poor quality drinking water

Figure 4 demonstrated the effects of waterborne diseases on households who suffered. Outcomes showed that 73.8% of the households responded that waterborne diseases influence their medical expenditures and 10.3% of the households stated that due to diseases their working efficiency reduced and they got absent due to illness, whereas, 15.8% responded that they face both problems (absentees and weakness). The ratio of absentees was more in rural (13.4%) as compared with urban (7.4%), whereas, a higher percentage (87%) of the urban households responded that they bear a high health cost burden.

Figure 4. Adverse Effect of Waterborne diseases on household suffers from poor water Quality

4.1. Bi-variate Analysis

The bi-variate analysis is a type of inferential statistical analysis that validates the relationship between variables. Table 5 disclosed the association between a household's drinking water facility and other socio-economic factors (income of the household, education, residential locality, water source, medical facilities, and medical expenditures due to water-related diseases). Chi-square value (145.90) and phi (0.49) showed that a strong relationship exists between the drinking water facility and household income, thus, rejecting H_0 (null hypothesis) and confirming the association through results. These results are in accordance with the findings of Zulfiqar et al. (2016) and Simelane et al. (2020), they also found similar outcomes. Gamma value (0.497) showed a positive association between the variables. Results of chi-square (465.61) disclosed that there exists a strong relationship between drinking water facilities owned by households and education facilities, gamma value (0.673) also confirmed that a strong positive association between variables. These types of outcomes were found by Ahmad and Sattar (2010).

Chi-square value (110.21) rejected the null hypothesis and proved that drinking water sources are influenced by the residential locality of the households. Gamma (0.379) and Phi (0.429) also validates the results. Chi-square 16.23(0.000) revealed that

residential locality and waterborne diseases were significantly related to each other. Thus, the findings support the H1 (alternative hypothesis) and validate that the incidence of waterborne diseases and locality of the households are interrelated. However, the gamma value 0.098 showed that both variables had a positive association between them. *Ceteris-Paribus*, the household with good water facilities also had good medical facilities and vice versa. Values of chi-square (442.158) and gamma (0.687) validates that drinking water facilities and medical care also had significant positive relationships. Aziz (2005) also found that sources of water and health are related to each other. Results concluded that the income, other facilities availed by households, and drinking water sources were significantly related to each other. Chi-square (53.07) and gamma (0.121) confirm that the water facility and medical expenditures also had a significant association between them. Nonetheless, the households who avail good drinking water facilities had more income, and the households with better income were concerned more about their health as a result take proper medication and avail better medical facilities (Malik et al., 2012) comprising higher cost as compared to the poor for the same treatment. Therefore, the incidence of cost applied to the households who were associated with paid water sources.

Table 5. Relationship between Drinking Water Facility, Health Expenditures, and Livelihood of Households

Associations among different variables	Chi-square	Contingency coefficient	Phi	Gamma
Income of households and drinking water facility	145.906 (0.000)	0.442 (0.000)	0.493 (0.000)	0.497 (0.000)
Education and drinking water facility	465.618 (0.000)	0.661 (0.000)	0.881 (0.000)	0.673 (0.000)
Residential locality and waterborne diseases	16.23 (0.013)	0.145 (0.005)	146 (0.005)	0.098 (0.140)
Residential locality and water source	110.21 (0.000)	0.394 (0.000)	0.429 (0.000)	0.379 (0.000)
Drinking water facility and medical care	442.158 (0.000)	0.651 (0.000)	0.858 (0.000)	0.687 (0.000)
Drinking water facility and medical expenditures due to waterborne diseases	53.07 (0.000)	0.345 (0.000)	0.367 (0.000)	0.121 (0.045)

*P-values are given in parenthesis

5. CONCLUSION

The study concludes that the household belonging to urban localities were more aware of health risks associated with drinking water quality. The incidence of waterborne disease was higher in rural households as compared with urban households. Outcomes revealed that household medical cost was significantly associated with drinking water sources. However, awareness was one of the major accelerating factors of consciousness of households about drinking water facility/source. There is a need to educate people regarding drinking water quality, for this purpose the media can play a positive role to create awareness about water contamination, quality, and its crucial importance.

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