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**Araştırma Makalesi • Research Article**

## **Analysis of Water Consumption in the Context of Public Health and Economics: The Case of Ankara**

### ***Su Tüketiminin Ekonomi ve Halk Sağlığı Bağlamında Analizi: Ankara Örneği***

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**Abstract:** This study aims to examine water consumption, which is the most basic necessity of people, within the framework of public health and economics. While water is an important economic research topic because it is the most important and most widely used economic good, it is also one of the most common medical research topics in the context of public health since it is consumed by all individuals of all societies. The use of packaged water in places where healthy tap water is inaccessible has positive effects on public health. On the other hand, the use of unnecessary packaged water is a very important public health problem in today's global world as it means more plastic waste. In our study, one of the most important variables affecting the consumption of packaged water, the parameter of trust in tap water, was analysed in Ankara by associating it with the concept of income level. As a result of the statistical analyses, it was determined that there was no statistical relationship between the income level with the use of packaged water and trust in tap water variables. In addition, it has been determined that there is a negative relationship between trust in tap water and packaging water usage variable. It is interesting that a result contrary to the established belief that income level is the main determinant of water usage preference has emerged.

**Keywords:** Water, Public Health, Income, Consumption

**Öz:** Bu çalışmanın amacı insanların en temel zorunlu ihtiyacı olan su tüketimini halk sağlığı ve ekonomi bilimi sistematığı içerisinde incelemektir. Su, en önemli ve kullanımı en yaygın ekonomik mal olması hasebiyle önemli bir ekonomik araştırma konusu iken, aynı zamanda tüm toplumların tüm bireyleri tarafından tüketildiği için de

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halk sağlığı bağlamında en yaygın tıbbi araştırma konularından birisidir. Sağlıklı şebeke suyunun ulaşılmaz olduğu yerlerde ambalajlı su kullanımının halk sağlığı üzerinde olumlu etkileri olmaktadır. Öte yandan gereksiz ambalajlı su kullanımı, daha fazla plastik atık anlamına geldiği için, günümüz global dünyasında çok önemli bir halk sağlığı sorunu olmaktadır. Çalışmamızda ambalajlı su tüketimini etkileyen değişkenlerin en önemlilerinden biri olan şebeke suyuna olan güven parametresi, gelir düzeyi kavramı ile ilişkilendirilerek, Ankara'da derinlemesine incelenmiştir. Yapılan istatistiksel analizler sonucunda gelir düzeyi ile ambalajlı su kullanımı ve şebeke suyuna güven değişkenleri arasında istatistiksel bir ilişki olmadığı tespit edilmiştir. Ayrıca, şebeke suyuna güven ile ambalajlı su kullanımı değişkenleri ise arasında negatif bir ilişki olduğu tespit edilmiştir. Bu sonuç gelir düzeyinin su kullanım tercihinin temel belirleyicisi olduğu şeklindeki yerleşik düşüncelerin aksi bir sonuç çıkması da ilginçtir.

**Anahtar Kelimeler:** Su, Halk Sağlığı, Gelir, Tüketim

### Introduction

Water is a clear thin liquid that has no colour or taste when it is pure. It falls from clouds as rain and enters rivers and seas. All animals and people need water in order to live (Rebelo and et. 2020). On the other hand; its formula is HOH, dielectric constant at 17 °C, its relative density under 81 atmospheric pressure at 4 °C is 1.00 d.n. Viscosity at 0 °C, 20 °C 0.01002 poise, specific heat 1 cal/g, vapor pressure at 100 °C 760 mmHg, surface tension at 20 °C 73 din/cm, melting point 80 cal/g, heat of vaporization 540 cal/g, refractive index 1.333, can be purified by distillation, ion exchange, chlorination and filtration, as suspending agent, solvent, industrial coolant, moderator in nuclear reactors, and physiologically nutritive, as well as power supply, water vapor production, paper coating, filtration. It is a colorless, odorless, tasteless, and most abundant liquid substance in the world (Kimya Terimleri Sözlüğü, 2022), which is widely used in washing and rubbing. It also has different names due to the differences in water production, use or composition such as distilled water, drinking water, utility water, waste water, sea water, heavy water and underground water. Water, whose chemical formula is H<sub>2</sub>O, is colorless, odorless, transparent, and liquid at room temperature under normal conditions. It is the only substance found in nature as liquid (water), solid (ice), and gas (water vapor, cloud) and it is connected to each other by the water cycle. As a molecular structure, two hydrogen atoms are attached to the oxygen atom at an angle of 104.95 degrees and the molecular size is given as 95.84 picometers (1 pm=10<sup>-12</sup> m). Molecules attract each other and tend to agglomerate. Due to the gravitational force when water particles are scattered on the surface (or in the air), they quickly agglomerate. With this feature, it has properties that are not found in other liquids. For example, having the highest surface tension after liquid mercury; such as its high hot collection capacity (it gives the seas a hot-holding feature), low temperature conductivity, the most dense liquid state among known liquids or having the highest evaporation enthalpy (Bishop and et., 2021).

Procurement of drinking water needs of the capital, which is Turkey's the second largest city with a population of five million, is an extremely important task. As we can see from the ancient ruins, serious investments have been needed to meet the water needs of this geography since the Roman period. Today, water security is carried out with the coordinated work of the Ministry of Agriculture and Forestry, special provincial administrations, the Metropolitan Municipality and the Ministry of Health. Finally, the mains (tap) water delivered to the households is under the responsibility of ASKİ, the institution of the Municipality (Tokmak and et., 2004). It is known that there are many factors that affect the taste of water. The most important one is the chlorine used as a water disinfectant, as well as other minerals and gases (such as CO<sub>2</sub>, SO<sub>4</sub>, H<sub>2</sub>CO<sub>3</sub>) in the water. From the physical properties of water to its chemical content, the perception of the consumer is also a factor (ASKİ, 2019). The taste properties of water are gathered under the concept of "organoleptic" [The ability of objects to affect the sense organs (Turkish Language Institution)].

Drinking/utilizing water must be clear. Even the appearance of turbidity in the water can cause a negative reaction, even before the consumer tastes or smells it. Common causes of turbidity include plant debris, microbial growth, and mineral sedimentation, such as iron and manganese . Turbidity is

measured in nephelometric turbidity units (NTU), and turbid water should never be consumed (Smith and et., 2023).

In general, drinking water between 8-16 °C is considered pleasant. Water above 25 °C is generally not pleasant and even might be described as nauseous. The amount of CO<sub>2</sub> should not be below 300 mg. Water, which is popularly described as smelling like slime or mold, is due to the mixing of gases such as sulfur dioxide and hydrogen sulfide while passing through deep layers (Koelmans and et., 2019). According to the data obtained from the publications, different threshold values for copper and iron ions, which are among the water flavoring agents, were also investigated and the following values were determined. As the average of the subjects, 0.031 – 0.05 mg in Fe and 0.61 mg in Cu were calculated.

Ankara's tap water is treated at the state-of-the-art İvedik Water Treatment Plant, one of the most advanced facilities of its kind in Turkey. The plant has a daily capacity of 1.5 million cubic meters and employs chlorination as its primary method of sanitation. The plant ensures that the chlorine levels in the water meet the guidelines set by the World Health Organization (WHO) of 0.3-0.5 parts per million (ppm) and the results of the analysis are regularly published on the website of the Ankara Water and Sewerage Administration (ASKI).

However, after the municipality began using water from the Kızılırmak River as the main source of tap water in Ankara following a severe drought in 2007, it was observed that many consumers approached drinking water with suspicion. One of the key objectives of this study is to investigate whether the aforementioned mistrust among consumers is related to the use of packaged water.

### Literature

The search for previous publications started with PubMed (Ekundayo, 2021). Around 12 000 publications are listed when searching only with “tap water”. On the other hand, only 178 publications appear in the search with “tap water perception”. There are 99 publications with the phrase “tap versus bottled water”. When it comes to the summaries of these publications, there are very few publications that overlap with our study (approximately 111). However, the Google search engine yields more than 20 million results. A search for “tap water perception” (organoleptic) yields 90 results (as of April 1, 2019) on Google [on the other hand, “tap water preference” yields 55 results]. The low results suggest that there are very few studies on raising awareness of the advantages of mains water or on using tap water. In the comparison of “tap water vs. packaged water” (tap water vs bottled water), Google gives more than 50 million (31 thousand when written in quotes).

The highlights of the publication scan are; in a survey conducted among well water users in Texas in 2018, 81% of the participants stated that they believed the water they used was of good quality. However, it was shown in the same study that 65% of the participants never had their well water tested (Halk Sağlığı Genel Müdürlüğü, 2019).

In the Gulf countries, it is thought that the consumption of drinking water treated from sea water leads consumers to use packaged water. Despite the removal of metal and organic substances in desalinated water, there are serious reservations about the taste of water among consumers. To overcome these, there is a more comprehensive study and public introduction of the organoleptic head in water quality monitoring (Tekbaş, 2010).

The study, which was conducted in Europe using a blind taste test method, revealed a range of responses from consumers regarding taste, health effects, and perceived risks. For instance, in the blind taste test, participants were unable to differentiate between tap water and bottled water using organoleptic evaluation techniques. In conclusion, the study demonstrates that tap water is in no way inferior to bottled water in terms of health benefits, and it is important to educate consumers on this (Güler, 2012).

According to a Canadian study, residents of the Ontario region were found to have a higher perceived risk of getting sick from tap water compared to those living in the Saskatchewan region. As a

result, Ontario region consumers reported a willingness to pay more for bottled water. This suggests that the difference may be attributed to social and cultural factors, as well as more effective marketing by municipalities (Omur-Ozbek and Dietrich, 2011).

The results of a survey of Purdue University students in Indiana, USA, revealed that female students had a stronger preference for bottled water than male students. The top reasons cited by students for their preference for bottled water were taste, perceived health benefits, and a sense of trust . The findings of the survey are believed to reflect behaviors that align with the messaging used in bottled water advertisements (Güler, 2012).

### Methodology

This study draws on a master's thesis, "Water Quality/Safety Perceptions Among People Using Tap Water in Metropolitan Ankara," which was completed by Rifat Pamuk in 2019 as part of the Public Health Program at Ankara Yıldırım Beyazıt University Health Sciences Institute. An electronic survey was conducted among 424 residents of the Ankara metropolitan area to explore their perceptions of the safety and quality of tap water distributed by the Ankara Water and Sewerage Administration (ASKİ). The İvedik Water Treatment Plant in Ankara is one of the most advanced facilities in Turkey and has a daily capacity of over 1.5 million cubic meters. The municipality monitors the water daily and likewise publishes the results on their webpage. The Ministry of Health also monitors the water from 1265 monitoring points across Ankara. Results from the survey showed that only 8.8% of participants preferred tap water, while 88.6% preferred bottled or home-filtered water for drinking. When asked why they did not consume tap water, 53.1% of respondents cited lack of trust in the water, while 31% cited dissatisfaction with its taste. Additionally, 37.1% of participants reported using tap water but still had a lack of trust in it.

The current study builds on the previous study by using the questionnaire data to perform further analysis, specifically, Chi-square tests (Pamuk,R 2019). As previously mentioned, the study employed a survey method to assess the preferences and satisfaction levels of tap water among Ankara residents. The survey questionnaire, which comprises 15 questions. The questionnaire addresses the preference of consumers for tap water or packaged water and examined the monthly expenses related to water and the income levels of the consumers, as well as the impact on the household budget. It seems appropriate to apply the survey to those living in 8 central districts of Ankara. The reason is that Ivedik Water treatment plant supplies approximately 90% of Ankara drinking water. The total population of eight districts is given as 4 735 531 people according to 2018 TUIK data. The address <https://select-statistics.co.uk/calculators/sample-size-calculator-population-proportion/> was used to find the number of subjects.

**Calculator**

What margin of error do you need? <small>5% is a common choice</small>	<input style="width: 50px;" type="text" value="5"/> %	
What confidence level do you need? <small>Typical choices are 90%, 95%, or 99%</small>	<input style="width: 50px;" type="text" value="95"/> %	
How big is the population? <small>If you don't know, use 100,000</small>	<input style="width: 100px;" type="text" value="4735531"/>	
What do you believe the likely sample proportion to be? <small>If you're not sure, leave this as 50%</small>	<input style="width: 50px;" type="text" value="50"/> %	
<b>Your recommended sample size is</b>	<b>385</b>	

**Figure 1. Sample Calculation**

Social media networks were used to attract attention of participants in the survey. Between 15 - 28 February 2019, 424 people participated in the survey. Although it was possible to reach the required number by sharing the link on social networks, it was not possible to intervene on the district breakdown.

### Results

When the monthly expenditures of all participants for Packaged water (average 87.82 ₺ (Türk Lirası, TL) , median 50 ₺) and the last water bill expenditures (average 105 ₺, median 85 ₺) are examined, it is clear that the Packaged water expenditure is higher (t.test  $p < 0.05$ ).

**Table 1.** Distribution According To Water Usage Preferences (N=409)

Drinking Water Preference	Number	Percent
Packaged	309	75,6%
Filter	53	13,0%
Tab	37	9,0%
Other	8	2,0%
Well	2	0,5%
Total	409	

The respondents are grouped according to their income. Based on the minimum wage being 2553₺

**Table 2.** Income Group (₺)

Income Group (₺)	Income	Average packaged water expenditure	Last water bill
A	Up to 2600 ₺	84.8 ₺	96.5 ₺
B	Between 2601 - 5100 ₺	74.2 ₺	85.3 ₺
C	Between 5101 – 8000 ₺	84.8 ₺	88.4 ₺
D	Between 8001 - 10 000 ₺	69.7 ₺	106.0 ₺
E	10 001 ₺ and more	88.3 ₺	97.0 ₺

When examining the data on income and trust variables in more detail, it was found that a total of 424 individuals responded to these questions. Income was queried in an open-ended format, resulting in a wide range of responses. As this variable is a continuous, rather than a categorical, variable. Assuming that the responses refer to monthly income, there were small incomes reported such as 0 (indicating 55 respondents were housewives), 68, and 500 (with 3 respondents each), as well as large incomes such as 50,000, 120,000 and 160,000 (with 1 respondent each). These values were excluded from the analysis since it is obvious that 0 does not reflect the real situation, and the specified extreme values may have an impact on the analyzes to be made because the variable is continuous.

The water distribution has 7 values of 0 and one missing data, these have not included in the analysis. There is one missing data in the confidence variable, it has not included in the analysis. When the above-mentioned values were excluded from the analysis, 355 questionnaires remained and analyzes were applied to these data.

### Descriptive Statistics;

The average income of 355 participants was 6079 ₺, the smallest 800 and the largest 25000 ₺. We can say that the skewness value is 1.66 skewed to the right, the kurtosis value is 4.14 sharp and the income variable does not conform to the normal distribution. In addition, the Kolmogorov-Smirnov test showed that the income distribution did not fit the normal distribution. For this reason, non-parametric tests were also included in the analyzes for the income variable.

**Table 3. Income**

N Valid	355
N Missing	0
Mean	6079,19
Median	5000,00
Mode	5000
Std. Deviation	3774,018
Skewness	1,666
Std. Error of Skewness	,129
Kurtosis	4,171
Std. Error of Kurtosis	,258
Minimum	800
Maximum	25000

Of the participants, 127 (35.8%) stated that they trusted, while 228 (64.2%) stated that they did not trust.

**Table 4. Confidence to main water**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I trust	127	35,8	35,8	35,8
	I dont trust	228	64,2	64,2	100,0
Total		355	100,0	100,0	

36 (10.1%) of the participants stated that they use mains water, 280 (78.9%) packaging and 39 (11%) filter water.

**Table 5. Water Choice**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Tap water	36	10,1	10,1	10,1
	Packaged	280	78,9	78,9	89,0
	filter	39	11,0	11,0	100,0
Total		355	100,0	100,0	

**Table 6. Income Range of Main Water Confidence (Income)**

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
I trust	127	6358,27	3594,704	318,978	5727,02	6989,52	1200	25000
I dont trust	228	5923,73	3869,306	256,251	5418,80	6428,67	800	25000
Total	355	6079,19	3774,018	200,304	5685,25	6473,12	800	25000

Considering whether there is a relationship between income and trust; While the average income of those who say they trust is 6358 ₺, the average income of those who say they do not trust is 5923 ₺.

ANOVA (parametric) and Kruskal Wallis (non-parametric – because the variable did not fit the normal distribution) tests were used to test whether there was a significant difference between the groups (May and Johnson, 1997). It was found as  $p=0.299$  in the ANOVA test and  $p=0.09$  in the Kruskal Wallis test. Since the  $p$  values of both tests were greater than 5%, it was decided that there was no significant relationship between income and trust.

Considering whether there is a relationship between the income level and the type of water consumed; The average income of those using tap water is 5295 ₺, the average income of those using packaged water is 6101 ₺, and the average income of those using filtered water is 6644 ₺.

ANOVA (parametric) and Kruskal Wallis (non-parametric – because the variable did not fit the normal distribution) tests were applied to test whether there was a significant difference between the groups. It was found as  $p=0.297$  in the ANOVA test, and  $p=0.232$  in the Kruskal Wallis test. Since the  $p$  values of both tests were greater than 5%, it was decided that there was no significant relationship between income and the type of water used.

The chi-square test was applied to assess the relationship between trust and the type of water consumed (Koliopoulos, 1990). The overall percentage of individuals using tap water is 10.1%, however, this increases to 18.1% among those who trust, and decreases to 5.7% among those who don't trust. While the general rate of those using packaged water is 78.9%, this rate is 70.1% for those who trust and 83.8% for those who do not. While the general rate of those using filter water is 11.0%, this rate is 11.8% for those who trust and 10.5% for those who do not. Since the  $p$  value of the chi-square test was less than 5%, it can be said that there is a relationship between the confidence and the type of water used. The results suggest that individuals who trust are more likely to prefer tap water over packaged water, compared to those who don't trust.

### Conclusion

As previously mentioned, there are no publications specifically addressing water expenditures or preferences in Ankara. However, some studies conducted in other regions can provide relevant insights. For instance, a survey conducted in West Virginia found that 37% of respondents reported consuming packaged water, while 58% preferred filtered water (Levegue JG,2017). In Gulf countries where drinking water is obtained from sea water, taste is a major concern for consumers, which has contributed to the high rate of packaged water consumption (Shomar B. 2017). In a survey conducted among students at Purdue University in the US state of Indiana, gender differences were observed in bottled water preferences. Female students showed a higher preference for bottled water compared to their male counterparts, citing taste, health perceptions, and trust as the primary reasons for their preference. The researchers also noted the impact of water advertisements on consumer behavior (Saylor A. 2011).

The first thing that stands out in the findings in our research is the high preference for packaged water instead of tap water. There are likely several reasons for this. First of all, taste is an important reason for preference. Although it is an extremely important disinfectant in terms of public health, the smell of the chlorine compound in the tap water is not welcomed by the consumers. Regardless of the reason, the interruption of the tap water immediately directs the consumers to the packaged water. The preference for packaged water can also be seen in the question of the usage time of the packaged water, which continues after the mains water comes in (average 10.2 years). According to widely accepted thought in literature especially the severe drought in 2007 suggests that people consume packaged water. Another possible reason is the sensational news about tap water. Even if there is news about water-borne diseases in any part of the country, directs Ankara consumers to packaged water (Tümer and et., 2011). Another important factor is advertisements. In the advertisements of packaged water, it is tried to call attention to consumers with messages such as health, source of life, very important for children. According to SUDER publications, it was reported that the packaged water market reached 4.2 billion ₺ in 2018. However, there is no advertisement for tap water, and also there is no positive news in the press.

As seen in the survey study, the consumption of tap water and the expenditure of packaged water in districts are quite close to each other (average bill). As income increases and distribution by districts, there is a slight tendency in favor of filter use in drinking water preference.

Statistical analysis of the findings indicates that trust is a key factor driving the high demand for packaged water. Our analysis revealed no correlation between income level and the type of water used

or income level and trust in tap water. More significantly, our analysis revealed a correlation between trust and the type of water used. It can be said that those who trust tap water prefer tap water more than those who do not, and those who do prefer packaged water less than those who do not. This finding contradicts the commonly held belief that packaged water is healthier. Sharing these findings and outcomes will have significant socio-economic impacts beyond public health. These outcomes will not only lower the public health risks associated with water usage, but also reduce the need for preventative and treatment measures in this field. This will provide a systematic alternative savings on public health expenditures. Public health bureaucracy will gain the opportunity to turn to other alternative risky issues.

The savings and alternative areas created by this switch will not be confined to public health, but will also have impacts on other socio-economic areas. For instance, expenses on packaged water constitute a significant proportion of the budgets of households in low-income groups. This usage, primarily as drinking water, falls under essential needs and offers little room for flexibility. However, in case of switching to the use of tap water, resource savings will be achieved for economic units, especially those with low incomes. The savings generated can be allocated towards other expenses.

It is important to note the global implications of switching to tap water from packaged water. The plastic packaging of water is a major global issue. Reducing consumption of packaged water results in less plastic use, a cleaner environment, and reduced expenses on pollution control.

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### **Beyan ve Açıklamalar (Disclosure Statements)**

1. Araştırmacıların katkı oranı beyanı / Contribution rate statement of researchers: Birinci yazar /First author %30, İkinci yazar/Second author % 40, üçüncü Yazar/Third author % 30.
2. Yazarlar tarafından herhangi bir çıkar çatışması beyan edilmemiştir (No potential conflict of interest was reported by the authors).