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Estimation of wasted water during tooth brushing determining the rate of taps open in Konya, Turkey

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Abstract
Aim: Konya province is one of the arid lands surrounded with high mountains in Central West Anatolia, Turkey. The level of underground water has been decreasing. Most of the consumption occur in agriculture, but household consumption is also crucial and should be managed for saving. Tap water is used carelessly for many purposes in houses. In this study, we aimed to estimate the wasted water during tooth brushing in Konya province and determine the rate of water consumption awareness.
Methods: This is a cross-sectional survey study conducted in restorative dental clinics with 1037 volunteer patients. The participants were asked about dental care behavior and the usage of tap during brushing.
Results: According to the results, we found that age, gender, education level, frequency and duration of tooth brushing were related with the awareness of using tap water significantly. We calculated the daily consumption per person using the rates and then, we estimated the annual wasted water during dental care in Konya as 210,000 m^3.
Conclusions: It is suggested that using excessive water should be avoided since it gets rid of the benefits of dentifrice, and the taps with innovative design for water saving should be used commonly.

Keywords: adult oral health, water, Turkey, tooth brushing

Introduction

Turkey is not abundant in natural resources. In addition, water is required not only for our country, but also all humanity. Although some parts of our country are abundant in water resources, some parts face the risk of drought. Konya province we live in is one of the leading dry lands both in our country and in the world. Konya is a city located in a huge plain encircled with high mountains in Central West Anatolia. Although it was a land abundant in groundwater resources, it has become in need of extra alkaline water transfer recently because of both climate change and incorrect agricultural irrigation. The level of water in wells providing drinking water has gone down below 100 meters. Besides the increase in areas abundant in salt level, many sinkholes have occurred. Some works have been performed in order to increase water supply in the area. Most of water consumption happen in agriculture. However, domestic and industrial consumption has also critical role. Besides expenses for providing new water resources, the existing water supplies should also be consumed in a thrifty way. Saving begins at home. Because tap water consumed at home is clean and drinkable. Water is consumed for washing clothes and dishes or various cleaning works. Tooth brushing is also one of these activities. As during having shower or shaving, some water is wasted during tooth brushing.

Mechanically fending off dental plaque by tooth brushing and other supportive methods are the most widespread suggested method in plaque control. As there are no chemotherapeutic agents completely preventing plaque biofilms in the mouth, the use of these tools become irreplaceable [1]. As plaque accumulation on tooth surfaces is one of the main reasons in formation of demineralization, mechanical plaque control has significant importance in tooth decay formation. It is known among routine dentistry that tooth brushing at least 2 times a day provides a highly efficient protection against periodontal and caries disease risks [2].

It has stated in the studies that women's oral health care is better than men's in same age group and the number of women's missing teeth is less than men's [3]. It has thought that the fact women's eating duration and frequency is longer helps modifying caries risk [4]. On the other hand, it's been pointed out in more recent studies that salivation secretion rate of women related to hormonal changes and changes in composition of saliva (especially during pregnancy) could increase caries risk [5]. Socioeconomic circumstances could be highly effective in oral health care factors [6]. Low socioeconomic level causes more decay, filled or missing teeth. Besides, in the studies, it was stated that there were no definite criteria in determining socioeconomic level and factors like parents' education level, level of income, number of individuals in the family, dwelling types, and diet were emphasized [7]. On the other hand, it has indicated that low socioeconomic circumstances are related to decay and bad oral health care, but the existence of cavity lesions at oral examination is a much more effective sign of risk than socioeconomic circumstance [8].

There are several studies about the household water consumption. These studies can be classified into two main subjects: to determine the attitude and behaviors towards water saving and to evaluate how the different ways of life affect the household water consumption. The research carried out to determine the relation between consumer's attitude and behaviors and environmental planning in order to determine water consumption has revealed how it affected decreasing

people's water consumption in regards to prices, regulations and availability in service delivery. The results of the study show that most of the dwellings are unsuccessful in decreasing water consumption. Water saving in real terms occurs with processing rainwater, recycling wastewater and use of more productive taps. Governments and relevant institutions should urgently take guiding decisions. With the help of sustainable educational campaigns, individuals' attitude and behavior towards water; saving could be positively changed [9].

The aim of this study is to estimate the wasted water during tooth brushing in Konya province and determine the rate of water consumption awareness.

Methods

Data Collection

The population for this research was obtained at five dental clinics in Turkey. A simple survey was conducted among 1037 patients. There was no randomization. All patients were asked to fill the form voluntarily during three months (February-April/2015) after getting the approval of ethics committee. We stopped to collect the data at the end of the April since we reached the desired sample size. We took into consideration the forms, which were answered completely. The questionnaire form consisted of some demographic information and several items about tooth brushing and water utilization (Table.4).

Statistical Evaluation

This is a cross-sectional study and the information was obtained from a survey. The number of participants was determined by simple random sampling method. All statistical analyses were performed by SPSS 20.0 software. The descriptive statistics were calculated for all variables. Categorical variables were presented as frequencies and ratios; continuous variables were presented as mean±sd (median, min, max) in tables and graphs. Numerical variables were examined whether they are distributed normally by Kolmogorov-Smirnov test. The reliability analysis of the survey data was done and Cronbach's alpha value was calculated. Student t-test for two independent groups and one-way ANOVA for multiple groups were performed to compare the differences between the groups. In case of no normal distribution, Mann-Whitney U and Kruskal-Wallis tests were preferred to compare the groups. Chi-square test with exact Monte Carlo simulation was used to see the relation between the categorical variables. Logistic regression analysis for open tap variable was modeled to determine the effects of other categorical variables and covariates. *p* value of less than 0.05 ($p<0.05$) was considered statistically significant for Type-I error level.

Results

We calculated that we would need 683 survey forms to estimate the consumed water. We considered the probability of the people who keep the tap open while tooth brushing as 0.20 with 80% power, 3% precision and at 5% significance level. Since the population of Konya province is greater than one million, we used the simple formula to determine the sample size as follows:

$$n = \frac{t^2_{\alpha/2} pq}{d^2} \qquad (3.1)$$

Although the formula 3.1 gave us, approximately 683 participants we decided to increase the sample size to increase the power of the study and to get results that are more accurate. The rate of the female participants (n=599, 57.8%) was greater than males (n=438). The majority of the participants was the graduates of primary school (n=516, 49.8%) and the rate of university graduates (n=291, 28.1%) was a little bit greater than high school graduates (n=230). The rate of those who are brushing their teeth was 85% (n=891) and the frequency of brushing were 37% for "rarely" and "daily" answers, and nearly 12% for "twice a week" and "2 or 3 times in a day" respectively. While the minority of the participants answered the question of "keeping the tap open" as "yes" (n=161, 15.5%), the durations of brushing were one minute (33.5%), 2 minutes (51.2%) and 3 minutes (15.3%) respectively. Age of the participants was the only continuous variable that we have. According to Kolmogorov-Smirnov test, age was not distributed normally (Z=1.692; p=0.002). Therefore, we used Mann-Whitney U test for comparing two independent groups and Kruskal-Wallis test for multiple independent groups with pairwise comparisons. According to the comparison tests, the difference of "age" between gender, education level, and brushing, frequency and duration groups was highly significant. However, age had no effect on the groups of "keeping the tap open". The age median of the patients who brush their teeth regularly was smaller. In frequency of brushing group, the greatest age median was in "rarely brushing" category. Similarly, the shortest duration of brushing was belonging to "1 min" group. The descriptive statistics and related *p* values are shown in Table.1 below.

Education level was strongly related with tooth brushing behaviors. The rate of the brushing participants was dramatically higher than non-brushing participants in each education level ($\boldsymbol{X}^2$=50.84; p<0.001). Moreover, the rate was increasing while the level was also increasing. The rates of the brushing patients who graduated from primary schools, high schools and universities were 77.7%, 93% and 94.8% respectively. There was a relation between education level and the frequency of brushing ($\boldsymbol{X}^2$=166.87; p<0.001). Most of the primary school graduates (54.1%) were brushing "rarely" whereas the majority of the university graduates (51.9% and 22.3%) were brushing "Daily" and "2-3 times in a day". Education level also influenced the habit of keeping the tap closed and the relation was significant ($\boldsymbol{X}^2$=4.046; p=0.044). The rate of the participants who answered as "No" for open-tap question were 82.6%, 84.3% and 88% for primary, high school and university level respectively. The duration of brushing had a significant relation with education level ($\boldsymbol{X}^2$=4.451; p=0.035). The lowest rate of both "1 min" and "2 mins" belonged to high school level, and the university graduates had the lowest rate in "3 mins" as shown in Figure.1 below.

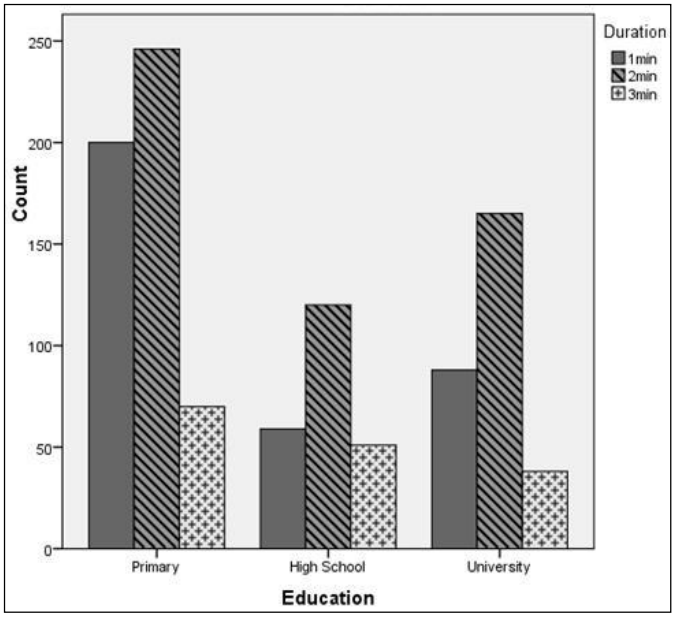

Fig 1: The duration of tooth brushing across the education groups

There was no significant relation between the brushing and open-tap question (X^2=1.727; p=0.189), but it was related with duration significantly (X^2=15.26; p<0.001). Nearly half of the participants were brushing their teeth during 2 minutes. Frequency of brushing was related with keeping the tap open significantly (X^2=6.405; p=0.011). The rate of participants (5%) who brush their teeth "2-3 times in a day" was significantly different from the rate of rarely (42.2%) brushing participants in open-tap group. There was a same proportional situation in close-tap group. The correlation among "tooth brushing" and "keeping the tap open" situations and answers to other questions were shown in Table 2.

There was a meaningful relation between gender and keeping the tap open (X^2=9.753; p=0.002). The rate of males keeping the tap open was higher (53.4%). On the other hand, the rate of females keeping the tap closed during tooth brushing was higher (59.8%). Examining complaints of patients answering the survey, it was seen that they mostly came with toothache. This problem was followed by decay, denture, gingival problems, filling and wisdom tooth. There was relation among complaint reasons and level of education (X^2=103.748; p<0.001), tooth brushing frequency 103.106; p<0.001), and duration of tooth brushing (X^2=58.860; p=0.035).

Some information is required in order to determine the wasted water because of keeping the tap on during tooth brushing. For this purpose, updated demographic information was taken belonging to central districts of Konya province from the webpage of Turkish Statistical Institute. Because of the belief that most of them do not have opportunity to brush their teeth, age groups of 0 to 4, 70 to 79 and over 80 were removed. It was determined from keeping the tap on table regarding gender that males had a rate of 53.4% females had a rate of 46.6%. The rate of keeping the tap on during tooth brushing was 15.5%. Average duration of tooth brushing was calculated as 1.82 minutes by using weighted mean. It was found as 109 seconds after converting. By measuring amount of the water during 109 seconds from 10 taps flushing in different amounts, the average was calculated and it was determined as 9.8 liters. How much water was consumed during per tooth brushing was calculated thinking the tap is turned on at the beginning of tooth brushing process and turned off at the end of the process. By using demographic numbers in regards of gender and by taking keeping the tap on rates into consideration, consumption for the whole population was calculated. These values were weighted with tooth brushing frequency and daily consumption amount was determined. The amount of wasted water around city center was estimated by converting consumption amount calculated for one year from liter to ton.

The population of women is 510,019 and 503,238 for men in Konya province as 5-70 age groups for the end of 2014 year. Therefore, the total consumption for women per one brushing is as follows

$$= 510,019 \times 15.5\% \times 9.8lt \times 46.6\%$$
$$\cong 361,019lt$$

Likewise, for men;

$$= 503,238 \times 15.5\% \times 9.8lt \times 53.4\%$$
$$\cong 408,200lt$$

Taking into consideration the frequency of brushing, we calculated the daily wasted consumption using the following Table.3:

Multiplying the grand total by 365 days, we got the annual wasted amount as

$$= 575,265 \times 365 = 209,971,725lt$$

And converting this number to m^3; we determined 209,972 m^3/year.

Discussion

The main object of this study was to determine the wasted water during tooth brushing. For this purpose, a survey was carried out with 1037 patients consulting for examination to the dental polyclinic. The patients were asked about their tooth brushing circumstances, keeping the tap on during tooth brushing circumstances and their tooth brushing frequencies. In addition to that, various demographic information of them were taken and its impact on tooth brushing habit and water consumption during tooth brushing habit was tried to be determined.

In domestic water consumption survey carried out in Queensland, Australia on 1985 citizens, 27 multiple-choice questions were asked to evaluate attitude and behavior towards water consumption. Correlations were tried to be found among various demographic and domestic information about water consumption and saving. Daily water saving behavior and intentions were tried to be evaluated and the attendees were asked to state their average water consumption in terms of liter. As a result of the study, database about water consumption and saving was obtained. It was understood that family extension and level of income affected water consumption, but gender didn't matter in consumption amount. On the other hand, turning off taps during tooth brushing doesn't matter in families consuming water in small, middle and large quantities [10]. Besides, in another study, it was revealed that families with high income consume more water than the ones with low

income. In addition to this, another reason affecting domestic water consumption is the number of family members. And the size of the house is also a significant reason. There are environments in these houses such as pools, steam baths, aquariums, ornamental pools which highly increase water consumption and they cause incautious water consumption [11]. Changing water consumption habits and managing consumption should be major policy. For this purpose, in a survey carried out in 10 OECD countries, attenders were asked what water saving practices they performed and its frequency. Behavioral patterns were tried to be estimated to save with ordered probity model by utilizing from water consumption information. Besides, money spent on water was included in the model. Volumetrically water amount variable was determined instead of consumed water amount and a dummy variable was used in the model as covariant. Negative correlation was obtained from the results between average water price and domestic water consumption. While awareness efforts for water consumption did not have positive effect on attitude towards water consumption, meaningful results were obtained between attitude towards water consumption and individuals having environmental consciousness or being a member of any organizations about it. Besides, as in dual flush toilet example, it was seen that using materials providing low water consumption has positive effect on water consumption patterns [12].

Relation between water consumption and health care was examined in a study with over 5000 pregnant women. They were both asked to keep a diary about water consumption and the difference was tried to be determined by conducting a survey. Although they stated the period of time in taking a shower as 15 to 20 minutes, they leave the water running for at least 5 minutes and they do similar activities. More than half of attendees estimated excessively in water consumption amount [13]. Individuals' attitude and intentions were researched with social marketing approach towards decreasing domestic water consumption. These attitudes are estimated with three major premises: individual's attitude towards behavior, social norms and perceived behavioral control level. In the generated model, it was revealed that they were all related to each other and only effort to change the attitude towards decreasing water consumption was not enough, it was required to change behavioral patterns towards perceived supervision of behavioral cognizance [14].

When drought occurs particularly in Mediterranean countries, difficulties are experienced in providing mains water and restrictions are performed. There should be an interactive information system between consumer and provider, because consumed water should be tracked. The consumed water is measured in terms of cubic meter and nobody thinks of converting into liter. This situation affects consumption psychologically. In order to use resources more effectively, consumers should share their experiences with each other. It's important to use technological opportunities with this aim [15].

Konya is one of the doughtiest cities in our country. Rainfall is variable from year to year; however, it is below the general average. On the other hand, water consumption consistently increases correspondingly with increase in population. As there are not grand drinking water resources around city center, people can only benefit from ground water. Besides water consumption over 2 billion m^3 because of agricultural irrigation, industrial water consumption is also high as medium scaled industry is also developed. That is why, saving water has significant importance. Demographic characteristics like level of income, level of education, expansion of family affect water consumption. In addition, technology for effectively consuming water decreases water consumption (10). Life style revealing because of luxury consumption such as bigger houses, decorative pools on the gardens, aquariums because of increases in level of income is one of the potential reasons of consuming water incautiously [11].

A negative correlation was tracked between high water prices and water consumption [9]. Gratfon *et al.* [12] found out that high water prices, devices to provide water saving and increase in environment consciousness significantly decrease water consumption because of their research. Two different approaches should be shown in order to decrease water consumption. Over consumption must be prevented with environment and saving consciousness to be raised beginning from young ages, and technological developments. In many cities, wasted water is refined and presented for reuse. Some studies were carried out about obtaining grey water with small-scaled of this system and every building is having its own water purifier [16]. In a different study, it is said that behavioral intentions and subjects approaches influence the reducing water consumption [14]. Moreover, householders should be informed with short time intervals how much energy they had used, so this information influences the consumption positively [15].

In our study, we found that younger people brush their teeth more than elderly people do and, besides, they brush more frequent and longer. Education level is important to care teeth since primary school graduates brush their teeth less and generally, it takes 2 mins to brush. Men tend to keep the tap open more than women do. The individuals having higher education level keep the tap closed during brushing. The duration is also important in wasting water since the participants brushing for 1 min do not care of keeping the tap closed whereas the participants brushing for 2 or 3 mins pay attention to close the tap. The results show that the residents in Konya province have consumer awareness positively. This situation may be resulted from either environmental consciousness or high water price (ca. 3 TRY/ m^3). However, we could not differentiate now the influence of both subjects on saving the water consumption.

One may study this research in a wider range as a future work. Although the ratio of the people who are particular about not to waste water during tooth brushing, there are still some things to do for this problem. Because the average of annual consumed tap water in Konya is approximately 80 million m^3. The last indicator was exactly 83,123,140 m^3 during 2013. The majority part belongs to household consumption and is about 64 million m^3. The remaining part is consumed in various fields such as schools, constructions, industry, religious buildings and parks. The annual wasted amount of water during tooth brushing is 3.2 per thousand (3.2‰) of household consumption and 2.5‰ of total consumption. In case of considering that Konya is an arid region, it can be realized how important annual 220 thousand tons of wasted water is. This amount was determined only for tooth brushing, unfortunately it is assumed that more than that amount is wasted during shower and shaving.

Therefore, it is highly recommended that the concept of protecting the environment and saving energy resources

should be instilled to people from early ages. Moreover, advanced technology should be used in water saving equipment and materials, and the projects should be supported in this area to reduce the prices, so the people can reach them easily. In another aspect, researchers say that teeth should be brushed more than once daily for dental health. But mouth rinsing with excessive water after brushing reduce the effect of fluoride dentifrice, and this should be avoided for maximal effect of fluoride toothpaste [17]. Hence, rinsing method should be given to the people, especially to the students, so that both less water would be consumed and the people would have healthier oral and dental care.

Table 1: The descriptive statistics of "Age" across categories of different groups*

		Mean ± SD	Median	Min	Max	p
Gender	Male	39.41±14.84	38	13	78	0.003
	Female	36.58±14.46	36	9	77	
Education	Primary [a, b]	41.85±14.60	42	9	78	<0.001
	High School [a, c]	31.67±14.29	31	13	72	
	University [b, c]	35.38±12.85	33	13	70	
Brushing	Yes	37.24±14.38	37	9	78	0.009
	No	41.04±16.08	40.50	13	77	
Frequency	Rarely [a, b, c]	41.10±15.44	40	9	77	<0.001
	Twice a week [a]	35.56±14.16	33.50	13	72	
	Daily [b, d]	35.48±13.69	36	9	78	
	2 or 3 times in a day [c, d]	32.78±13.70	29	13	69	
Open tap	Yes	37.61±16.48	35	11	77	0.620
	No	37.81±14.34	38	9	78	
Duration	1 mn [a, b]	39.75±14.37	39	9	78	0.002
	2 mns [a]	37.32±14.48	36	9	77	
	3 mns [b]	32.58±15.53	33	13	70	

Table 2: Frequencies and ratios of attributes across brushing and keeping the tap open cases

		Brushing (N %)			Open-tap (N %)		
		Yes	No	p	Yes	No	p
Gender	Male	369 (41.4%)	69 (%47.3)	0.185	86 (53.4%)[a]	352 (40.2%)[a]	0.002
	Female	522 (58.6%)	77 (52.7%)		75 (46.6%)	524 (59.8%)	
Education	Primary	401 (45%)[a]	115 (78.8%)[a]	<0.001	90 (55.9%)[a]	426 (48.6%)[a]	0.044
	High School	214 (24%)	16 (11%)		36 (22.4%)	194 (22.1%)	
	University	276 (31%)	15 (10.3%)		35 (21.7%)	256 (29.2%)	
Frequency	Rarely	254 (28.5%)[a]	129 (88.4%)[a]	<0.001	68 (42.2%)	315 (36%)	0.011
	Twice a week	131 (14.7%)	15 (10.3%)		27 (16.8%)	119 (13.6%)	
	Daily	389 (43.7%)[b]	2 (1.4%)[b]		58 (36%)	333 (38%)	
	2 or 3 times in a day	117 (13.1%)	0 (0%)		8 (5%)[a]	109 (12.4%)[a]	
Open-tap	Yes	133 (14.9%)	28 (19.2%)	0.189	……	……	…..
	No	758 (85.1%)	118 (80.8%)		…..	……	
Duration	1 mn	276 (31%)[a]	71 (48.6%)[a]	<0.001	79 (49.1%)[a]	268 (30.6%)[a]	<0.001
	2 mns	471 (52.9%)[b]	60 (41.1%)[b]		63 (39.1%)	468 (53.4%)	
	3 mns	144 (16.2%)	15 (10.3%)		19 (11.8%)[b]	140 (16%)[b]	

Table 3: Calculation of total daily consumption of water during tooth brushing

Frequency	Ratio	For Women	Total
Rarely	37%	$=361,019\times37\%\times(1/7)\cong19,082lt$	*269,990 lt*
Twice a week	14%	$=361,019\times14\%\times(2/7)\cong14,441lt$	
Daily	38%	$=361,019\times38\%\times(1)\cong137,187lt$	
2-3 times in a day	11%	$=361,019\times11\%\times(2.5)\cong99,280lt$	
		For Men	
Rarely	37%	$=408,200\times37\%\times(1/7)\cong21,576lt$	*305,275 lt*
Twice a week	14%	$=408,200\times14\%\times(2/7)\cong16,328lt$	
Daily	38%	$=408,200\times38\%\times(1)=155,116lt$	
2-3 times in a day	11%	$=408,200\times11\%\times(2.5)=112,255lt$	
Grand Total			*575,265 lt*

Table 4: The Questionnaire Form

NECMETTİN ERBAKAN UNIVERSITY

FACULTY OF DENTISTRY TOOTHBRUSHING QUESTINNAIRE

Dear participant,
This form was constructed to determine the relation between the tooth brushing habits and the water consumption. Your valuable and correct answers will increase the quality of the study and help to obtain the significant results. Do not write down your name on the form. Your information will be kept confidential and will not be shared by third party.

Age: …….	**District: ……**	**Complaint: ……**	
Gender:	a) Male	b) Female	
Education level:	a) Primary	b) High school	c) University
Do you brush your teeth?	a) Yes	b) No	
Frequency of toothbrushing?	a) Rarely	b) Twice a week	
	c) Daily	d) 2-3 times in a day	
Do you keep the tap open while toothbrushing?	a) Yes	b) No	
How long does your toothbrushing take? (average minutes)	a) 1 min	b) 2 mins	c) 3 mins

Conflict of Interest

The authors declare that they have no conflict of interest.

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