

Biomonitoring of tobacco smoke exposure and self-reported smoking status among general population of Tehran, Iran

Mohammad Hoseini¹ · Masud Yunesian^{2,3} · Ramin Nabizadeh^{2,3} ·
Kamyar Yaghmaeian^{2,4} · Saeid Parmy² · Hamed Gharibi⁵ · Sasan Faridi² ·
Mohammad Sadegh Hasanvand³ · Reza Ahmadkhaniha⁶ · Noushin Rastkari³ ·
Nezam Mirzaei⁷ · Kazem Naddafi^{2,3}

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Abstract The present study aimed to find a correlation between the self-reported smoking status of the residents of Tehran, Iran, and the urine cotinine as a biomarker of exposure to tobacco smoke. The self-reported data was collected from 222 participants who were living in the urban area of Tehran. The urine samples of participants were collected for cotinine analysis. Urine cotinine was measured by an enzymatic immunoassay technique. Tobacco smoking was reported by 76 (34.23 %) participants as the self-reported data, and the number of males in this report was higher than of females

($p < 0.001$). By adding the number of the self-reported non-smokers with cotinine levels above the cutoff value of >100 ng/ml to self-reported smokers, the smoking prevalence increased from 34.23 % (95 % CI 28.01–40.88 %) to 36.48 % (95 % CI 30.14–43.19 %). Using the cutoff value, sensitivity and specificity of the self-reported smoking status were respectively 90.12 % (95 % CI 81.46–95.64 %) and 98 % (95 % CI 93.91–99.55 %). The levels of agreement between self-reported tobacco smoking and urinary cotinine concentrations was 95.1 % ($k = 0.89$, $p < 0.001$, 95 % CI = 0.81–0.95).

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✉ Kazem Naddafi
knadafi@tums.ac.ir

Mohammad Hoseini
m_hoseini2174@yahoo.com

Masud Yunesian
yunesian@tums.ac.ir

Ramin Nabizadeh
mabizadeh@tums.ac.ir

Kamyar Yaghmaeian
kyaghmaeian@gmail.com

Saeid Parmy
s.parmy@yahoo.com

Hamed Gharibi
gharibi65@gmail.com

Sasan Faridi
sasanfaridi@yahoo.com

Mohammad Sadegh Hasanvand
mshasanvand@yahoo.com

Reza Ahmadkhaniha
r-ahmadkhaniha@tums.ac.ir

Noushin Rastkari
n.rastkari@yahoo.com

Nezam Mirzaei
nezammirzaei@yahoo.com

¹ Department of Environmental Health Engineering, School of Public Health, Shiraz University of Medical Sciences, Shiraz, Iran

² Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

³ Center for Air Pollution Research (CAPR), Institute for Environmental Research (IER), Tehran University of Medical Sciences, Tehran, Iran

⁴ Center for Water Quality Research, Institute of Environmental Research (IER), Tehran University of Medical Sciences, Tehran, Iran

⁵ Health Sciences Research Institute, University of California, Merced, CA, USA

⁶ Department of Human Ecology, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

⁷ Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran

Based on the results, self-reported smoking can be a valid marker for assessing the tobacco exposure, and it can be of use in large epidemiological studies.

Keywords Cotinine · Cigarette smoking · Water pipe smoking · Tobacco exposure

Introduction

One of the most important public health issues is tobacco smoking. The smoke from tobacco has been identified as a leading factor to many diseases, including cardiovascular and respiratory diseases and several types of cancer (i.e., lung cancer, cancers of the larynx and mouth, esophageal cancer, and pancreatic cancer) (Chiu et al. 2008; Homayoun-Vash et al. 2008; Montalto and Wells 2007). According to WHO reports, nearly six million dies each year caused by using tobacco; in fact, more than five million of these deaths are related to directly smoking tobacco and also, more than 600,000 are caused by exposure to environmental tobacco smoke (ETS) (Organization 2008). In spite of public awareness about the adverse health effects regarding the use of tobacco, some people still smoke either actively or passively. It should also be taken into consideration that there no applicable and acceptable method can measure its true exposure level (Pearce et al. 2014; Willers et al. 2000). In many previously conducted studies, self-administered questionnaires have been used to evaluate smoking status. Self-reporting, however, can be considered as an imprecise indicator of true exposure level; in other words, questionnaires could be subjected to misclassification or recall bias (Jhun et al. 2010; McDonald et al. 2003; Okoli et al. 2007). Recently, to validate the reports resulted from applying the mentioned method to evaluate smoking status and exposure to smoke from tobacco, measuring cotinine (i.e., a major proximate metabolite of nicotine) has been suggested (Chiu et al. 2008; Kvalvik et al. 2012; Wong et al. 2012).

The appropriate specificity and sensitivity of cotinine, and its in vivo half-life (i.e., 16 to 18 h), makes this compound a very efficient biomarker; besides, cotinine is less influenced by environmental variables. Cotinine can be measured in different body fluids, including blood, urine, and saliva, as well as in hair and nails (Florescu et al. 2009; Montalto and Wells 2007). It should be mentioned that the choice of matrices for cotinine measurement depends mainly on practical rather than pharmacokinetic considerations. In fact, no uniform and standardized cutoff values are available at the levels of cotinine in different matrices. However, a urinary cotinine concentration of 100 ng/ml has been used to classify people as current smokers and non-smokers (McDonald et al. 2003). In previously conducted studies, smokers and non-smokers were distinguished from each other by setting a urinary cotinine

concentration cut point of 50 ng/ml (Jung-Choi et al. 2012; Wong et al. 2012). The serum and saliva cotinine concentrations have also been measured in previous studies. In these studies, the cutoff levels considered as the discriminator between current smokers and non-smokers were between 3 and 45.5 ng/ml (Rebagliato 2002).

It has been reported that cigarette smoking is common among Iranian people with current and daily smoking rates of 12.5 % (23.4 % males and 1.4 % females) and 11.3 % (21.4 males and 1.4 females). These reports, however, are mostly deduced from filling questionnaires; in other words, the validity of these reports, considering the abovementioned issues around the applied questionnaires, has not been evaluated (Meysamie et al. 2012).

This study aimed to investigate the relationship of self-reported exposure to tobacco smoke (e.g., cigarette and water pipe) and the urinary cotinine levels among the residents of Tehran, Iran. It is noteworthy that Tehran is one of the largest and most populated cities on earth with the population of 11 million. In this study, specific questions about smoking were asked; cotinine concentrations in spot urine samples, which were collected at the time of filling the questionnaire, were measured.

Materials and methods

Recruiting the subjects and collecting data

The present work is a cross-sectional study that was conducted in Tehran, Iran, between 2013 and 2014. Tehran, the capital of Iran and one of the most crowded cities in the Middle East, with a population of around ten million, is located 35° 34–35° 50' latitude and 51° 08–51° 37' longitude (Hoseini et al. 2016; Kamani et al. 2014). This study was conducted on 222 subjects that were randomly chosen in a door knock survey started from 10 a.m. to 8 p.m. In other words, we selected random points, which were weighted based on the population plotted on Tehran population density layer using Arc GIS software, and then, home address with respect to the points were individually chosen. To collect the required spot urine samples, a resident per each address was randomly chosen to participate in this study; after receiving the consent of each chosen resident, a sample was taken from each one. It is noteworthy that each sample was immediately stored at –20 °C for thereafter analysis. In addition, we asked all the subjects to fill a detailed questionnaire aimed to document their personal and sociodemographic information, smoking history/exposure, cooking-related appliances, activities, and consumed foodstuff. The present work was approved and coded (24039) by the Ethics Committee of Tehran University of Medical Sciences.

Questionnaire

As mentioned above, one of the parts of the questionnaire was related to the “smoking history/exposure.” In this part, the subjects were required to answer 14 questions that are shown in Table 1. To determine the ETS exposure, the sum of hours per day at which the subjects were exposed to tobacco smoke at both work and home was calculated. Furthermore, the required data in this study was collected by conducting face-to-face interviews with participants.

Analyzing urinary cotinine and creatinine in the collected samples

All urine samples were collected in 70-mL urine bottles that were wrapped in aluminum foil to avoid sunlight exposure and labeled with the subject specifications. The collected urine samples were divided onsite into three aliquots and kept in a portable cool box containing icepacks (at about 2–8 °C) to deliver the box to the laboratory for further analyses. Two of the aliquots were used to analyze the concentration of urinary creatinine and cotinine; the third one was kept frozen to measure the hydroxylated metabolites of PAHs (OH-PAHs). Based on an enzymatic immunoassay technique, a competitive ELISA kit was applied to measure the concentrations of urinary cotinine in the samples (Abnova Cutinize ELISA kit, KA1416). For urinary creatinine, we applied the Jaffe’s method (i.e., photometrical measurement) to determine its concentration, and then, the measured concentration of cotinine was normalized with the one determined for

the urinary creatinine. Based on the reports of previous studies in this field, urinary cotinine concentration >100 ng/ml shows that one is a smoker. In this regard, we also used this limit to distinguish the smokers from the non-smokers.

Statistical analysis

Urinary cotinine concentrations (mean ± SD) and smoking status of the subjects were reported according to their gender. Based on self-reported data, the subjects were distinguished and put into the following categories: smoker, including cigarette and/or water pipe smokers (i.e., an instrument used for smoking flavored tobacco); non-smokers; and passive smokers. Furthermore, the smoker group was divided into three categories, including cigarette smokers, water pipe smokers, and those who smoke both cigarette and water pipe. Correlation between urinary cotinine concentration and numbers of cigarettes smoked per day was assessed using Spearman’s correlation coefficient with 95 % CI; the Mann-Whitney U test was applied to differentiate the groups. In order to estimate the specificity and sensitivity of self-reported data, the urinary cotinine cutoff value (>100 ng/ml) was applied. It should be mentioned that the specificity is in fact the percentage of the subjects whose urinary cotinine concentrations are below above the mentioned cutoff value and correctly and truthfully stated that they have never smoked tobacco, and also, sensitivity is the percentage of the subjects who correctly reported (self-report) a tobacco smoking status and their urinary cotinine concentrations are above the cutoff value (Kvalvik et al. 2012). In addition, the level at which the self-reported smoking status and urinary cotinine concentrations were in line with each other was evaluated using the Kappa and four other measures of association, including the positive predictive value, the negative predictive value, the positive likelihood ratio, and the negative likelihood ratio. All analyses were performed using R statistical software. For all statistical analyses, the significance level was set at $P < 0.05$.

Table 1 Questions asked from the participants in this study

Do you smoke cigarette?

How many cigarettes do you smoke a day?

How many cigarettes did you smoke 48 h ago?

Are you currently using the Nicorette gum, patch, or other pharmaceutical device to help you stop smoking?

Does a household member smoke cigarettes in your home?

Can you please tell me the number of smokers in your home?

Were you exposed to cigarettes smoke 48 h ago in your home?

In your home, how many hours per day are you exposed to cigarette smoke?

Has anyone in your workplace smoked in your presence?

Can you please tell me the number of smokers in your workplace?

In your workplace, about how many hours a day are you exposed to cigarettes smoke?

Do you smoke water pipe?

How many water pipes do you smoke a day?

How many water pipes did you smoke 48 h ago?

Does a household member smoke water pipe in your home?

In your home, about how many hours a day are you exposed to water-pipe smoke?

Results

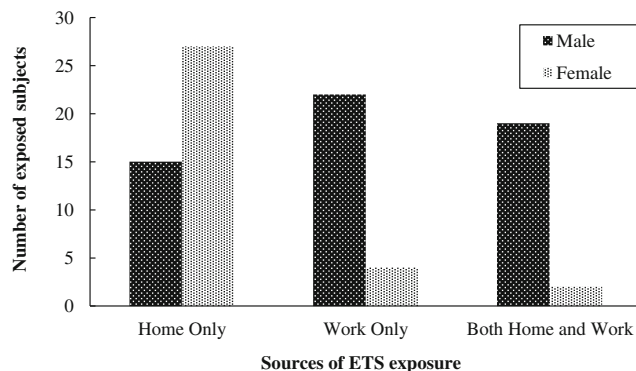
Population characteristics and self-reported tobacco exposure status

Table 2 indicates the characteristics and self-reported smoking status of the subjects who participated in this study, which was consisted of 130 males and 92 females. Of the 222 subjects who consented to participate in this study, 76 (59 men and 17 women) reported (self-reported) that they smoke tobacco (cigarette and/or water pipe). Compared with the types of smoking tobacco in other countries, the number of those who were using water pipe as tobacco smoking was found among the study population to be very high. The prevalence rates of smoking water-pipe tobacco in male and female subjects were respectively 19.2

Table 2 Self-reported tobacco exposure according to different characteristics in Tehran

Characteristics	N (%)					
	Total	Smoker			Passive smoker	Non-smoker
		Cigarette smokers only	Water pipe smokers only	Both cigarette and water pipe smokers		
All participants	222 (100)	39 (17.6)	19 (8.6)	18 (8.1)	57 (25.7)	89 (40.1)
Male	130 (58.6)	34 (26.2)	9 (6.9)	16 (12.3)	27 (20.8)	44 (33.8)
Female	92 (41.4)	5 (5.4)	10 (10.9)	2 (2.2)	30 (32.6)	45 (48.9)
Age (years)						
<15	24 (10.8)	1 (4.2)	0 (0.0)	0 (0.0)	10 (41.7)	13 (54.1)
15–24	39 (17.6)	3 (7.7)	9 (23.1)	8 (20.5)	10 (25.6)	9 (23.1)
25–44	116 (52.2)	28 (24.1)	9 (7.8)	8 (6.9)	31 (26.7)	40 (34.5)
45–65	38 (17.1)	6 (15.8)	1 (2.6)	2 (5.3)	6 (15.8)	23 (60.5)
>65	5 (2.3)	1 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (80.0)
BMI (kg/m ²)						
<18.5	13 (5.9)	0 (0)	2 (15.4)	1 (7.7)	4 (30.8)	6 (46.1)
18.5–25	114 (51.4)	23 (20.2)	10 (8.8)	7 (6.1)	33 (28.9)	41(36.0)
>25	95 (42.7)	16 (16.8)	7 (7.4)	10 (10.5)	20 (21.1)	42 (44.2)
Education						
High school diploma or less	141 (63.5)	27 (19.1)	15 (10.6)	11 (7.8)	31 (22.1)	57 (40.4)
Bachelor's degree	62 (27.9)	9 (14.5)	4 (6.5)	7 (11.3)	20 (32.2)	22 (35.5)
Master's degree	19 (8.6)	3 (15.8)	0 (0.0)	0 (0.0)	6 (31.6)	10 (52.6)

and 13.04 %. The mean age of the subjects who reported to be tobacco and non-tobacco smokers were 31.9 and 32.6 years, respectively. In addition, it was found that the cigarette and water pipe smokers started smoking tobacco at the age of 13 and 15, respectively. Based on the self-reported data, the average number of cigarettes smoked per day by the cigarette smokers was 8.36; besides, water pipe smokers stated that they smoke an average of 1.43 water pipes per day. In addition, the number of reported cigarettes smoked per day by each gender is shown in Fig. 1. As shown in this figure, the majority of these subjects smoked between five and ten cigarettes per day. As also can be seen from the figure, there is a significant difference in the number of cigarettes smoked per day by male and female subjects (Mann-Whitney U test $P < 0.01$). However, the number of used

**Fig. 1** Frequency of reported cigarettes smoked per day by gender

water pipes per day did not differ between the genders (Mann-Whitney U test $P > 0.01$). Regarding the educational level of the subjects, as shown in the Table 2, the less educated ones smoked more cigarettes than did those with higher education. The same trend was also observed among the water pipe smokers. Of the 57 participants with passive tobacco smoke exposure, 43 (75.4 %) and 9 (15.8 %) reported passive smoking of cigarettes and passive smoking of water pipes, respectively; in addition, 5 participants (8.8 %) reported passive smoking of both cigarettes and water pipes. The number of subjects who were being regularly exposed to ETS, based on the source of exposure and gender, is shown in Fig. 2. Regarding the ETS exposure in the

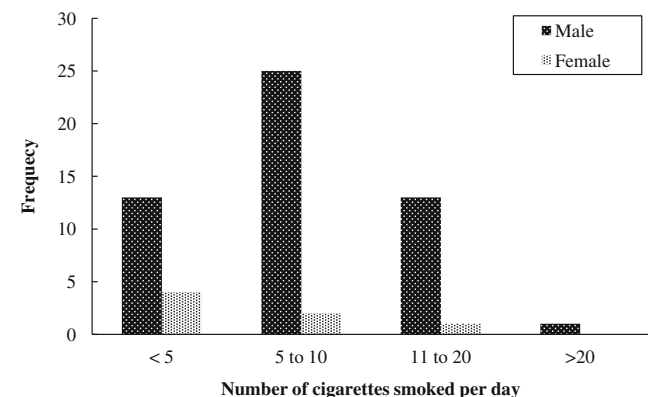
**Fig. 2** Number of subjects reporting regular exposure to ETS by source of exposure and gender

Table 3 Self-reported tobacco exposure status by urine cotinine category

Categories	Self-reported tobacco exposure status					Total
	Cigarette smoker	Water pipe smoker	Both cigarette and water pipe smoker	Passive smoker	Non-tobacco user	
Cotinine <100 ng/ml						
Male	1	0	1	24	43	69
Female	0	0	0	26	46	72
Total	2	0	1	50	88	141
Cotinine >100 ng/ml						
Male	33	9	15	3	1	61
Female	5	9	2	4	0	20
Total	38	18	17	7	1	81

home only, the number of females reporting regular exposure to ETS in the home only was significantly higher, compared to that of the males ($p < 0.05$). However, a significantly higher number of males ($p < 0.01$) reporting exposure to ETS at the work only was observed, compared to the number of females. Furthermore, it was found that none of the participants uses smokeless nicotine products such as chewing tobacco or snuff, nicotine chewing gum, etc.

Cotinine concentrations and self-reported smoking status

As mentioned above, self-reported smoking status of the subjects was compared to the cutoff of their urinary cotinine concentrations, which is shown in Table 3. Based on the results, of the 146 participants who had never smoked tobacco according to their own self-reports, the cotinine concentrations of 8 participants were above the cutoff value of >100 ng/ml (Table 4). The corresponding discordance rate was 5.48 %. The cotinine concentrations of the participants with disagreement between the questionnaire and the cotinine cutoff values were not at the borderline, and the cotinine values measured in them were in the range of 178.3 to 786.2 ng/ml with an average of 488.4 ng/ml. Also, the creatinine-adjusted cotinine values ranged from 162.1 to 1545.4 ng/g creatinine with an average of 693.5 μg/g creatinine. In addition, of the 76 participants who self-reported smoking status, the urinary cotinine value of 73 was >100 ng/ml while the cotinine concentrations of the other 3 were below the cutoff

value. The related discordance rate calculated for these results is 3.95 %. The mean sensitivity and specificity determined for the self-reported data in this regard were 90.12 % (95 % CI 81.46–95.64 %) and 97.88 % (95 % CI 93.90–99.55 %), respectively. Based on the results, the levels of agreement between self-reported tobacco smoking and urinary cotinine concentrations was 95.1 % ($k = 0.89$, 95 % CI: 0.81–0.95, $p < 0.001$), and the total misclassification rate was 4.9 % (11 participants). The positive and negative predictive values were 0.96 (95 % CI 0.89–0.99) and 0.95 (95 % CI 0.89, 0.98), respectively. Considering the positive and negative likelihood ratios of 42.36 (95 % CI: 13.80, 130.06) and 0.10 (95 % CI: 0.05, 0.19), respectively, and the high kappa coefficient of 0.89, it can be implied that the agreement of self-reported smoking status with urinary cotinine concentrations is high.

Cotinine and creatinine-adjusted cotinine concentrations

The average concentrations of urinary cotinine and creatinine-adjusted cotinine in the smoking and non-smoking groups are indicated in Table 5. There were significant differences ($p < 0.01$) among the different smoking status groups. As shown in Table 5, the urinary cotinine levels of the water pipe smokers were approximately 1.4 times higher than of the cigarette smokers. Based on the self-reported number of water pipes used per day, the urine cotinine concentrations of the water pipe smokers are shown in Fig. 3. The average concentration of

Table 4 Comparison of self-reported smoking status with urinary cotinine measurements

Self-reported smoking status	Cotinine-verified smoking status		Total	Likelihood ratio
	Smoker	Non-smoker		
Smoker	73 (32.88)	3 (1.35)	76 (34.23)	42.36
Non-smoker	8 (3.61)	138 (62.15)	146 (65.77)	0.1
Total	81 (36.49)	141 (63.51)	222 (100)	

Sensitivity 0.90 (95 % CI 0.81–0.96), specificity 0.98 (95 % CI 0.94–1.00), positive predictive value 0.96 (95 % CI 0.89–0.99), negative predictive value 0.95 (95 % CI 0.89, 0.98), kappa 0.89 (95 % CI 0.81–0.95)

Table 5 Concentrations of urinary cotinine and creatinine adjusted cotinine (mean \pm SD) in different smoking and non-smoking groups

Groups	Number	Cotinine concentration (ng/ml)	Creatinine adjusted cotinine (μ g/g)
Tobacco users	76	795.6 \pm 396.7	882.17 \pm 491.97
Cigarette smokers	41	661.5 \pm 360.4	683.4 \pm 294.7
<10 cigarettes/day	23	538.6 \pm 330.36	547.2 \pm 272.8
10–20 cigarettes/day	16	853.6 \pm 327.4	896.4 \pm 182.2
>20 cigarettes/day	2	927.4 \pm 363.8	1114.8 \pm 90.6
Water-pipe smokers	19	900.1 \pm 407.1	1057.6 \pm 680.9
Both cigarette and water pipe users	16	1053.6 \pm 265.8	1226.1 \pm 322.1
Passive tobacco smoke exposure ^a	50	7.6 \pm 2.8	5.4 \pm 2.2
Non-tobacco users ^b	88	3.56 \pm 1.9	3.38 \pm 1.3

^a Excluded seven subjects with cotinine values above 100 ng/ml

^b Excluded one subject with cotinine value above 100 ng/ml

urinary cotinine of the water pipe smokers was considerably higher than the corresponding amount measured in the cigarette smokers who smoked less than ten cigarettes per day.

Figure 4 shows the relationship between urinary cotinine concentrations in cigarette smokers and data gathered from filled questionnaires regarding the number of cigarettes smoked per day. As shown in the figure, urinary cotinine and creatinine-adjusted cotinine concentrations increase significantly when the number of cigarettes smoked per day increases as well. In fact, urine cotinine was highly and positively correlated (Spearman) with the number of cigarettes smoked per day; but, it was found that the correlation with creatinine-adjusted cotinine concentration ($r = 0.74$, 95 % CI 0.58–0.87, $p < 0.001$) is stronger than that with urine cotinine concentration alone ($r = 0.71$, 95 % CI 0.52–0.85, $p < 0.001$). Regarding the passive smokers, a highly significant correlation ($r = 0.76$, 95 % CI 0.57–0.87, $p < 0.001$) was found

between the cotinine concentrations and reported duration of being exposed to tobacco smoke (Fig. 5).

Discussion

The results of assessing the self-reported data in this study showed that the prevalence of smoking among the Tehran residents is 34.23 % (95 % CI: 28–41 %). By adding the self-reported non-smokers whose cotinine levels were above the cutoff value to the self-reported smokers, the prevalence increases from 34.23 % (95 % CI 28–41 %) to 36.48 % (95 % CI 0.30, 0.43), which is much higher than that being reported in Iran (10.8–15.3 %) (Amin-Esmacili et al. 2013; Meysamie et al. 2010; 2012) and in various regions studied previously around the world (15–26 %) (Al-Turki 2006; Andrade et al. 2006; Man et al. 2009; Thompson et al. 2007). This difference could be due to the fact that cigarette smoking was only focused on in previously conducted studies; in other words, the other types of smoking (e.g., water pipe smoking), which was assessed in this study, have not been taken into account in those studies. Also, it is possible that the difference in the definitions of daily smoking and smoking status rendered in each study resulted in various forms of results. Regarding the age at which one starts smoking, cigarette smokers started at younger age, compared to the related age of water pipe smokers; in other words, it can be implied that those who started smoking cigarette at an earlier age would prefer to smoke cigarette rather than water pipe. Considering the abovementioned ages of starting tobacco smoking, it can be said that no effective national programs and policies can lower the number of children and youths smoking tobacco in any form. Based on the results, we suggest that any attempt to propose such programs should mainly target the males.

Valid monitoring of smoking status in a population is very essential in conducting epidemiological studies. In the present

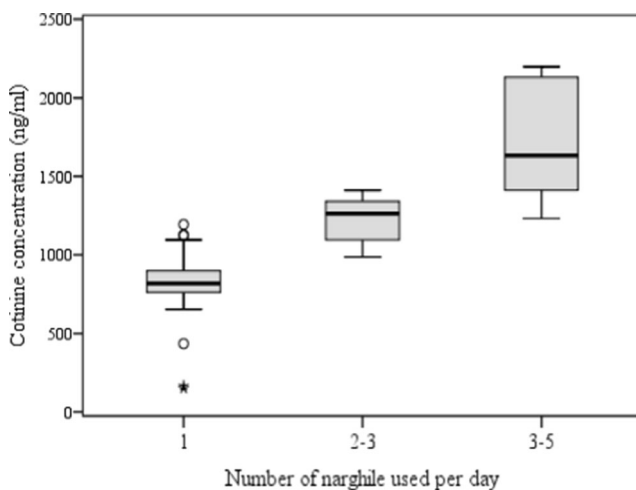
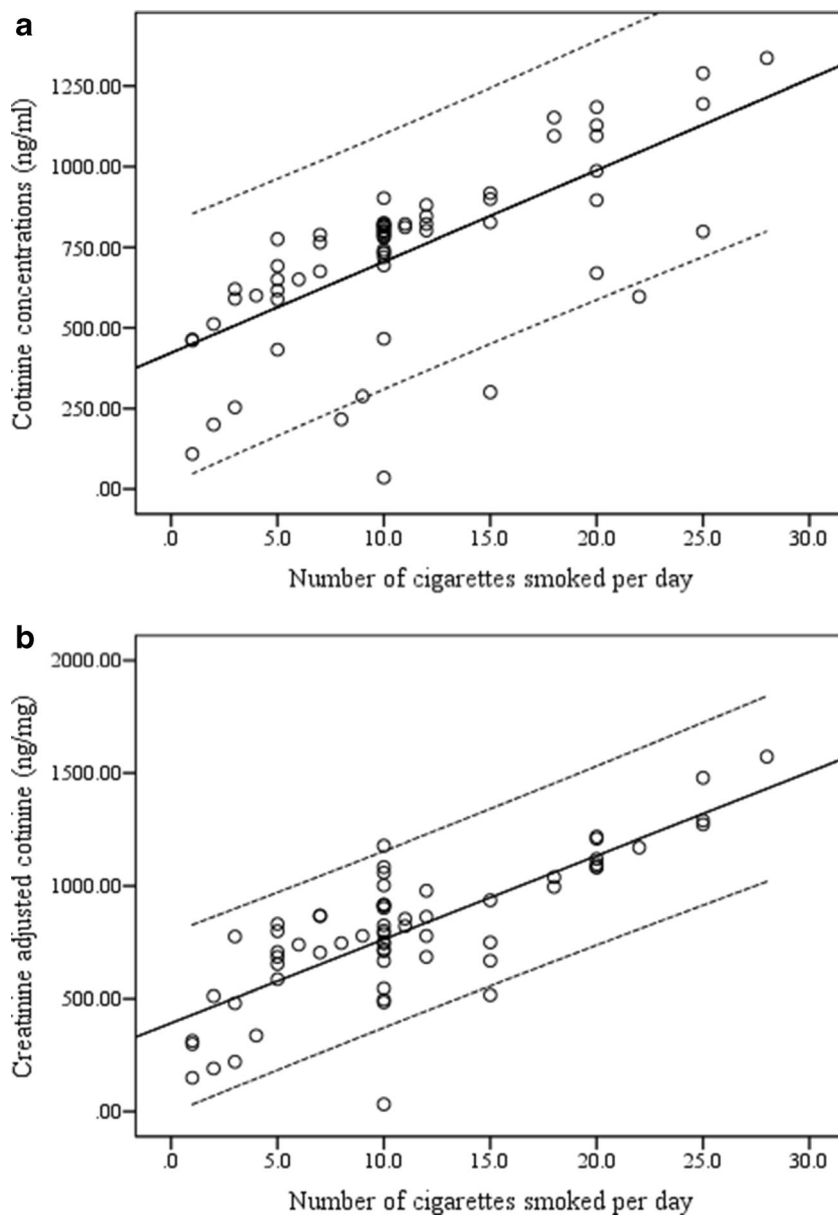


Fig. 3 Urinary cotinine concentrations in narghile smokers based on self-reported number of narghiles smoked per day

Fig. 4 Relationship between urinary cotinine (a) and creatinine-adjusted cotinine (b) concentrations in cigarette smokers and the self-reported number of cigarettes smoked per day



study, it was found that the overall misclassification rate is very low (4.94 %) and self-reported smoking status has a specificity and a sensitivity of 97.88 % (CI 93.90–99.55 %) and 90.12 % (CI 81.46–95.64 %), respectively. In other words, it can be speculated that a questionnaire can be applied to document self-reports of the subjects and classify the smoking status among them. The rate of misclassification among the smokers and non-smokers were 3.95 and 5.48 %, respectively, which is in line with the results of a study conducted by Wells et al. (1.3–26.2 %) in a non-community setting (Wells et al. 1998). The higher discrepancy among self-reported non-smokers could be due to the social stigma. The sensitivity obtained in this study is higher than that reported by Kvalvik et al. (82 %) who validated self-reported smoking status against plasma cotinine concentrations among

Norwegian pregnant women (Kvalvik et al. 2012). These results are in contrast with the reports of a conducted study by Jhun et al., on Korean pregnant women. In their study on pregnant women, the kappa coefficient of agreement between self-reported smoking status and urinary cotinine concentrations was found to be 0.20 (Jhun et al. 2010). However, the results relating to this issue are in line with the findings of several studies conducted previously (Gorber et al. 2009; Lee et al. 2013; Parker et al. 2002).

The increase in the concentrations of urinary cotinine in this study was according to the following order: non-smokers < passive smokers < smokers. Although cotinine concentrations in cigarette smokers have been studied widely, to the best of our knowledge, there is no information on the other forms of tobacco smoking (e.g., water pipe); in fact, other

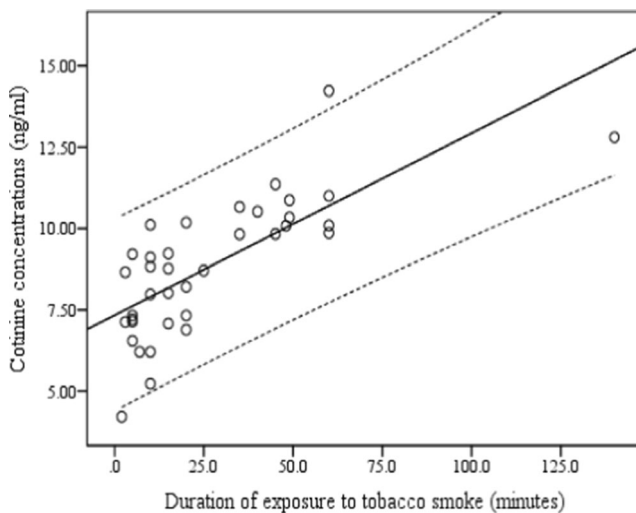


Fig. 5 Relationship between urinary cotinine concentrations in passive smokers and the duration of exposure to ETS

forms of smoking tobacco are mostly prevalent in certain parts of the world. Considering this, the results indicated that water pipe smokers have higher cotinine compared to cigarette smokers. It is noteworthy that the nicotine content of tobacco used to prepare water pipe is higher than its corresponding amount in cigarettes. Besides, the amount of tobacco used in the water pipe has been reported to be 10 to 20 g, in comparison with the 1 to 1.5 g used in a cigarette (Knishkowsky and Amitai 2005). In fact, this could be the reason why water pipe smokers have such high cotinine levels. It is commonly believed that smoking water pipe has lesser adverse effects compared to cigarette smoking, since the water filters the smoke of the tobacco before being inhaled. However, water pipe and cigarette smokers are exposed to the same level of harms (Hemat et al. 2012). Considering the amount of tobacco used to prepare a water pipe, it can be deduced that smoking a water pipe equates with smoking 20 cigarettes. In general, depending on the number of cigarettes and water pipe smoked per day, the level of urinary cotinine in smokers is approximately 150 to 290 times higher than its level in non-smokers. The levels of cotinine found in different groups of cigarette smokers were similar to those reported by Man et al. However, urinary cotinine levels found among the water pipe smokers in this study were lower than among those reported in a study conducted in India (Behera et al. 2003). This could be due to the difference in the duration of smoking, depth, length, and frequency of inhaling water-pipe smoke.

In this study, there was no statistically significant correlation between the number of smokers at home and/or work and urinary cotinine concentrations among passive smokers; in other words, cotinine concentrations among the passive smokers depend on other parameters as well rather than the number of smokers living near the subjects. On one hand, a statistically significant correlation exists between urinary cotinine levels and the duration of exposure to tobacco smoke,

suggesting that the concentration of urinary cotinine depends mainly on the duration of exposure; on the other hand, the other parameters, including individual variability in nicotine uptake, metabolism, and elimination rate, are of importance and should be taken into account (Hukkanen et al. 2005; Man et al. 2009).

Conclusion

In this cross-sectional study, we tried to validate self-reported smoking status by using urinary cotinine measurement in 222 participants in Tehran, Iran. Self-reported data regarding cigarette smoking, water pipe smoking, and passive smoking were collected in detail and validated using urinary cotinine measurement. The limitation of this study is that the role of exposure for the passive smokers to smoke outside their home and work office/places was not assessed. However, the main point of strength of this study is the simultaneous collection of baseline questionnaires and urine samples. In fact, this point is very important in epidemiologic studies because smoking behavior may change over the time, leading to errors in the association measures. It should be mentioned that this study is the first attempt to validate the prevalence rate of smoking in Tehran, Iran, based on self-report. In conclusion, the results showed that self-reported smoking status in Tehran residents had a high sensitivity as well as specificity implying that self-reported smoking is a valid marker for tobacco exposure, even when it is assessed as a part of a broader questionnaire.

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References

- Al-Turki YA (2006) Smoking habits among medical students in central Saudi Arabia. *Saudi Med J* 27:700–703
- Amin-Esmaeili M, Rahimi-Movaghar A, Yunesian M, Sahimi-Izadian E, Moinolghorabaei M (2013) Trend of smoking among students of Tehran University of Medical Sciences: results from four consecutive surveys from 2006 to 2009. *Med J Islam Repub Iran* 27:168
- Andrade APA, Bernardo ACC, Viegas CAA, Ferreira DBL, Gomes TC, Sales MR (2006) Prevalence and characteristics of smoking among youth attending the University of Brasília in Brazil. *J Bras Pneumol* 32:23–28
- Behera D, Uppal R, Majumdar S (2003) Urinary levels of nicotine & cotinine in tobacco users. *Indian J Med Res* 118:129–133
- Chiu H-T, Wu H-DI, Kuo H-W (2008) The relationship between self-reported tobacco exposure and cotinines in urine and blood for pregnant women. *Sci Total Environ* 406:331–336
- Florescu A, Ferrence R, Einarson T, Selby P, Soldin O, Koren G (2009) Methods for quantification of exposure to cigarette smoking and

- environmental tobacco smoke: focus on developmental toxicology. *Ther Drug Monit* 31:14
- Gorber SC, Schofield-Hurwitz S, Hardt J, Levasseur G, Tremblay M (2009) The accuracy of self-reported smoking: a systematic review of the relationship between self-reported and cotinine-assessed smoking status. *Nicotine Tob Res* 11:12–24
- Hemat H, Wittsiepe J, Wilhelm M, Müller J, Göen T (2012) High levels of 1-hydroxypyrene and hydroxyphenanthrenes in urine of children and adults from Afghanistan. *J Expo Sci Environ Epidemiol* 22:46–51
- Homayoun-Vash J, Asghari F, Forouzanfar MH, Hosseinpoor AR, Farhud D (2008) Smoking-related respiratory symptoms in Tehran: a cross-sectional study. *Arch Iran Med* 11:507–514
- Hoseini M, Yunesian M, Nabizadeh R, Yaghmaeian K, Ahmadkhaniha R, Rastkari N, Parmy S, Faridi S, Rafiee A, Naddafi K (2016) Characterization and risk assessment of polycyclic aromatic hydrocarbons (PAHs) in urban atmospheric particulate of Tehran, Iran. *Environ Sci Pollut Res* 23:1820–1832
- Hukkanen J, Jacob P, Benowitz NL (2005) Metabolism and disposition kinetics of nicotine. *Pharmacol Rev* 57:79–115
- Jhun H-J, Seo H-G, Lee D-H, Sung M-W, Kang Y-D, Syn HC, Jun JK (2010) Self-reported smoking and urinary cotinine levels among pregnant women in Korea and factors associated with smoking during pregnancy. *J Korean Med Sci* 25:752–757
- Jung-Choi K-H, Khang Y-H, Cho H-J (2012) Hidden female smokers in Asia: a comparison of self-reported with cotinine-verified smoking prevalence rates in representative national data from an Asian population. *Tob Control* 21:536–542
- Kamani H, Hoseini M, Safari GH, Jaafari J, Mahvi AH (2014) Study of trace elements in wet atmospheric precipitation in Tehran, Iran. *Environ Monit Assess* 186:5059–5067
- Knishkowsky B, Amitai Y (2005) Water-pipe (narghile) smoking: an emerging health risk behavior. *Pediatrics* 116:e113–e119
- Kvalvik LG, Nilsen RM, Skjærven R, Vollset SE, Midttun Ø, Ueland PM, Haug K (2012) Self-reported smoking status and plasma cotinine concentrations among pregnant women in the Norwegian mother and child cohort study. *Pediatr Res* 72:101–107
- Lee A, Gin T, Chui PT, Tan PE, Chiu CH, Tam TP, Samy W (2013) The accuracy of urinary cotinine immunoassay test strip as an add-on test to self-reported smoking before major elective surgery. *Nicotine Tob Res* 15:1690–1695
- Man CN, Fathelrahman AI, Harn GL, Lajis R, Samin ASM, Omar M, Awang R, Bayanuddin NA (2009) Correlation between urinary nicotine, cotinine and self-reported smoking status among educated young adults. *Environ Toxicol Pharmacol* 28:92–96
- McDonald SP, Maguire GP, Hoy WE (2003) Validation of self-reported cigarette smoking in a remote Australian aboriginal community. *Aust N Z J Public Health* 27:57–60
- Meysamie A, Ghaletaki R, Haghazali M, Asgari F, Rashidi A, Khalilzadeh O, Esteghamati A, Abbasi M (2010) Pattern of tobacco use among the Iranian adult population: results of the national survey of risk factors of non-communicable diseases (SuRFNCD-2007). *Tob Control* 19:125–128
- Meysamie A, Ghaletaki R, Zhand N, Abbasi M (2012) Cigarette smoking in Iran. *Iran J Publ Health* 41:1
- Montalto NJ, Wells WO (2007) Validation of self-reported smoking status using saliva cotinine: a rapid semiquantitative dipstick method. *Cancer Epidemiol Biomark Prev* 16:1858–1862
- Okoli CT, Kelly T, Hahn EJ (2007) Secondhand smoke and nicotine exposure: a brief review. *Addict Behav* 32:1977–1988
- Organization WH (2008): WHO report on the global tobacco epidemic, 2008: the MPOWER package
- Parker DR, Lasater TM, Windsor R, Wilkins J, Upegui DI, Heimdal J (2002) The accuracy of self-reported smoking status assessed by cotinine test strips. *Nicotine Tob Res* 4:305–309
- Pearce MS, Mann KD, Singh G, Davison B, Sayers SM (2014) Prevalence and validity of self-reported smoking in indigenous and non-indigenous young adults in the Australian northern territory. *BMC Public Health* 14:861
- Rebagliato M (2002) Validation of self reported smoking. *J Epidemiol Community Health* 56:163–164
- Thompson B, Coronado G, Chen L, Thompson LA, Halperin A, Jaffe R, McAfee T, Zbikowski SM (2007) Prevalence and characteristics of smokers at 30 Pacific northwest colleges and universities. *Nicotine Tob Res* 9:429–438
- Wells AJ, English PB, Posner SF, Wagenknecht LE, Perez-Stable EJ (1998) Misclassification rates for current smokers misclassified as nonsmokers. *Am J Public Health* 88:1503–1509
- Willers S, Axmon A, Feyerabend C, Nielsen J, Skarping G, Skerfving S (2000) Assessment of environmental tobacco smoke exposure in children with asthmatic symptoms by questionnaire and cotinine concentrations in plasma, saliva, and urine. *J Clin Epidemiol* 53: 715–721
- Wong SL, Malaisson E, Hammond D, Leatherdale ST (2012): Secondhand smoke exposure among Canadians: cotinine and self-report measures from the Canadian Health Measures Survey 2007–2009. *nicotine & tobacco research*, nts195