Original Article

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Determination of the Relation Between Passive Cigarette Smoking in Children and Respiratory Tract Infections by Evaluation of Urine Cotinine/Creatinine Levels

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Abstract

Aim: Passive smoking is an important public health issue due to the clinical problems it causes. In this study, we determined the effect of passive smoking on respiratory tract infections using a survey method, family history, and urine cotinine/creatinine ratio.

Methods: Seventy-two children who came to the Pediatric Outpatient Clinic at Istanbul Bagcilar Training and Research Hospital for a check-up with no current health problems between November 2020 and March 2021 were included in this prospective cross-sectional study. The study group included 36 children with at least one active smoker in the house, and the control group included 36 children with no active smokers in the house. With the survey, sociodemographic variables about the family and child as well as the frequency of lower or upper respiratory tract infection history were questioned. Cotinine and creatinine levels were measured using the urine samples of the patients included in the study.

Results: The frequency of respiratory tract infections in the last two years was increased in the group with an active smoker in the household. The frequency of bronchopneumonia in the case group was 44.4%, whereas it was 5.6% in the control group. The sinus infection was seen in 22.2% of those in the case group, while there were no sinus infections reported in the control group. Bronchopneumonia and sinus infections were statistically significant in the case group ($p<0.01$ and $p<0.01$ respectively). The median cotinine levels in the active smokers in the house group were 20.94 ng/mL (0-491) and 16.62 ng/mL (0-121) in the nonsmoker group. 55.6% of children with a history of cigarette smoke exposure and a urine cotinine level higher than 10 ng/mL were considered passive smokers (the normal range is 0-10 ng/mL).

Conclusion: Frequent respiratory tract infections and hospitalization may be prevented by informing families about the risks of exposure to cigarette smoke as well as raising awareness of the harms of cigarette smoke.

Keywords: Children, passive cigarette smoking exposure, respiratory tract infection, urine cotinine, urine cotinine/creatinine

Introduction

Exposure to cigarette smoke is critical since it is very common, but also preventable. According to the report on the Global Tobacco Outbreak by the World Health Organization (WHO) in 2017, tobacco use causes more than 7 million deaths per year. One in every ten deaths is caused by tobacco usage. Furthermore, 600,000 (170,000 children) of these deaths are the result of passive smoking. WHO also reports that 700 million children are exposed to cigarette smoke by 1.2 billion smokers, mainly in their home environment (1).

Passive smoking is defined as even though the person does not actively smoke, is exposed to cigarette smoke in closed environments and inhales all the harmful substances in the smoke (2). The prevalence of passive smoking in children is very high, especially in developing countries, and is reported as 29-69%. According to studies

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in our country, 14.8 million people use tobacco products, and of those, 94.8% smoke cigarettes. Passive smoking in children is reported as 53-92% (3,4).

Passive smoking has become a major health problem since people spend most of their time in closed environments (5). Passive smoking, which is as harmful as active cigarette smoking, causes important health issues in children. It increases and facilitates upper and lower respiratory tract diseases starting from early childhood. Passive cigarette smoking significantly increases hospitalization and health expenses in children due to respiratory system diseases (6).

The most reliable and important biological indicator of exposure to cigarette smoke and active smoking is cotinine. Cotinine is the major metabolite of nicotine. In cases where obtaining a 24-hour urine sample is impossible, urine cotinine levels and cotinine/creatinine ratios are the most appropriate gatherable data for the determination of exposure to the cigarette.

This study aims to compare the urine cotinine levels and cotinine/creatinine ratios with the results of the survey to determine passive smoking exposure more objectively in children aged 2-5 years, and to evaluate the relationship between passive smoking exposure and respiratory tract infections.

Methods

Ethical Standards

The study was approved by the Istanbul Bagcilar Training and Research Hospital Clinical Studies Ethical Board on September 11th, 2020, with the number 2020.09.2.07.124. Certain questions were asked by the families of those included, and families were informed that a urine sample would be collected from their children. A written consent form was obtained from all the families.

Study Design

Seventy two children who came to the pediatric outpatient clinic at University of Health Sciences Turkey, Istanbul Bagcilar Training and Research Hospital, for a check-up with no current health problems between November 2020 and March 2021 were included in this prospective cross-sectional study. Children were divided into two groups based on whether they were exposed to cigarette smoke or not. Thirty six children between the ages of 2-5 years old were reported as passive smokers, with at least one active smoker in the household, and 36 children in the same age range were included as non-passive smokers. This age range was selected because of the fact that children between the ages of 2 and 5 are more susceptible to cigarette smoking and are less likely to be exposed to external factors since they do not attend school.

The data was collected by the researcher herself, using a face-to-face interview technique. In the survey, the relation of the child and interviewee, child's age, number of siblings, occupation of mother and father, education of mother and father, type of the house they live in, the ventilation system of the house, the heating system of the house, whether mother or father are smokers, if they are smoker number of cigarettes smoked per day, whether other people in the house smoke, if there are; the number of cigarettes they smoke, the total number of cigarettes smoked in the house per day, whether cigarette was being smoked in the same room as the child, number of people the child shares the room with, if the child or any other member of the family has a history of any disease that require prescription drugs or routine controls, whether the child had any respiratory tract infection within the past two years, if the answer is yes, how many times and what kind were asked.

Collection of Urine Samples

Gathering samples with a urine bag interferes with the laboratory standardization of urinalysis. Therefore, the samples were collected using urine cups. To evaluate the cotinine levels, at least 5 cc of urine samples were collected in urine cups with no preservatives and placed in +4 °C refrigerators. They were centrifuged at 4000 cycles for 20 min, then the supernatant parts were separated. All the samples were frozen at -80 °C. Following the collection of all samples, the urine samples were defrosted at room temperature. The supernatant parts were again separated and the samples were placed in the devices. Urine cotinine levels were studied using a DPC labeled Immulite 2000 device (Siemens, USA) using the chemiluminescence immunoassay method. Urine creatinine levels were measured using the Beckman Olympus AU 5800 device.

Cotinine levels lower than 10 ng/mL were accepted to signify no contact or very little contact with cigarette smoke. Values between 10-500 ng/ml signified passive smoking. Urine cotinine levels higher than 500ng/ml were accepted as active smoking (7).

Statistical Analysis

For statistical analysis, the NCSS (Number Cruncher Statistical System) program was used. Complementary statistical methods (mean, standard deviation, median, frequency, percentage, minimum, maximum) were used while evaluating the data. The Shapiro-Wilk test and graphical analysis were used to determine the suitability of quantitative data for normal distribution. A Mann-Whitney U test was used to compare the two groups of data that did not have a normal distribution. The Pearson chi-square test, Fisher's-exact test, and Fisher-Freeman-Halton tests were also used to compare

the quantitative data. Statistical meaningfulness was accepted as p<0.05.

Results

The study was conducted with a pediatric population of 72 children, 47.2% (n=34) female and 52.8% (n=38) male patients. The children were aged between 2 and 5 years old, with an average of 4,014±0.99 years. 50% of the children (n=36) did not have an active smoker at home, while the other 50% (n=36) had at least one active smoker at home. In houses with smokers, the mother was the smoker in 5.6% (n=2), the father was the smoker in 69.4% (n=25), both parents were smokers in 11.1% (n=4) and 13.9% (n=5), another person in the house was the smoker (Table 1) (Figure 1). The number of cigarettes smoked per day ranged between 2 and 40, with an average of 11.89±8.86.

The average age of the study group was 4,014±0.97 and the average age of the control group was 4,014±1.02 with no statistically meaningful difference in age between both groups (p>0.05). There were 14 female and 22 male patients in the study group, and 20 female and 16 male patients in the control group. There was no statistically meaningful difference in the gender distribution of both groups (p>0.05) (Table 2).

Socio-demographic data of the control group and those exposed to passive cigarette smoking are shown in Table 2.

There was a statistically meaningful difference in the work status of mothers (p=0.014; p<0.05). The proportion of working mothers in the study group was significantly higher than that in the control group (Table 2).

The groups' backgrounds (personal and family history) were compared. The history of respiratory tract infections was found to be statistically meaningfully high in the study group compared to the control group (p=0.008; p<0.01) (Table 3).

Table 1. According to the survey results, smoking in the home

		n	(%)
House status	Smokers	36	(50)
	Non-smokers	36	(50)
Person who smokes (n=36)	Mother	2	(5.6)
	Father	25	(69.4)
	Mother+father	4	(11.1)
	Other	5	(13.9)
Daily cigarette smoking	Average ± standard deviation	11.89±8.86	
	Median (minimum-maximum)	10 (2-40)	

Table 3, shows the comparison of the number and types of respiratory tract infections over the past two years for both groups. The number of respiratory tract infections over the past 2 years was statistically meaningfully high in the study group (p=0.001) (Figure 2).

Comparing the types of infections in each group showed that there was no statistically meaningful difference in the occurrence of tonsillitis, pharyngitis, and bronchiolitis (p>0.05) whereas bronchopneumonia and sinusitis were statistically meaningfully higher in the study group (p<0.01, p<0.01 respectively) (Figure 3).

Urine cotinine levels of children in the study ranged between 0 and 491.16 with an average of 49.60±89.20. 44.4% (n=32) had no contact (0-10) whilst 55.6% (n=40) was passive smoker (Table 4).

Once the groups were compared on the basis of urine cotinine and urine cotinine/creatinine ratios, there was no statistically meaningful difference found (p>0.05, p>0.05 respectively) (Table 5).

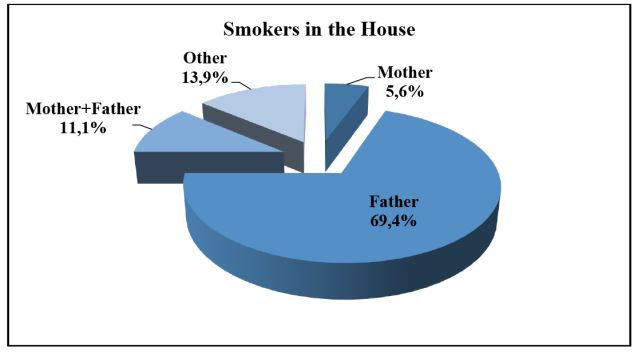

Figure 1. Distribution based on smokers in the house

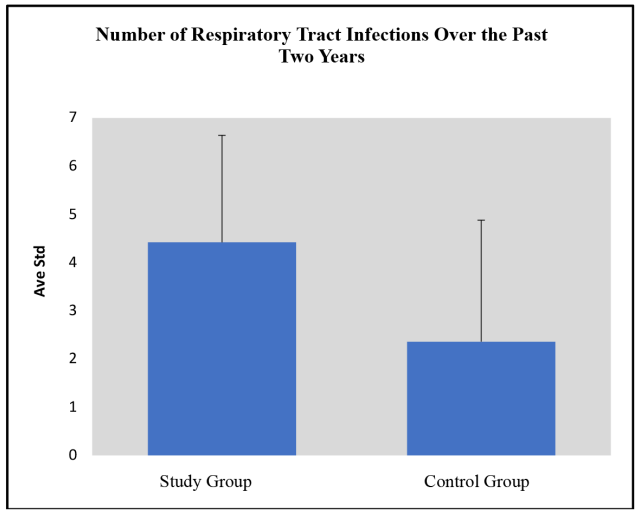

Figure 2. Distribution of the groups based on the number of respiratory tract infection in the past two years

Discussion

Passive cigarette smoking is one of the subjects that is highly discussed sociologically, legally, and medically. Children are exposed to passive smoking through different routes. The pediatric population is mostly passive smokers due to close relatives who smoke. It is caused by the mother being a passive or active cigarette smoker during prenatal time or the child being exposed to cigarette smoke postnatally by a smoking parent or another family member (8). Passive smoking may cause various health issues in children. Both intrauterine and postnatal passive cigarette exposure increase the frequency of respiratory

Table 2. Comparison of both groups based on epidemiological and socio-demographic data

		Study (n=36)	Control (n=36)	p-value
Age	**Average ± Standard deviation**	4.014±0.97	4.014±1.02	[a]**0.958**
Sex, n (%)	**Female** **Male**	14 (38.9) 22 (61.1)	20 (55.6) 16 (44.4)	[b]**0.157**
Number of siblings, n (%)	**None** **1** **2** **≥3**	8 (22.2) 14 (38.9) 9 (25) 5 (13.9)	4 (11.1) 17 (47.2) 8 (22.2) 7 (19.4)	[b]**0.569**
Number of people the child shares the room with, n (%)	**None**	1 (2.8)	1 (2.8)	[c]**0.328**
	1	2 (5.6)	4 (11.1)	
	2	8 (22.2)	15 (41.7)	
	3	17 (47.2)	12 (33.3)	
	4	4 (11.1)	3 (8.3)	
	5	4 (11.1)	1 (2.8)	
Number of people in the house. n (%)	**3 People**	7 (19.4)	4 (11.1)	[b]**0.200**
	4 People	9 (25)	16 (44.4)	
	5 People	20 (55.6)	16 (44.4)	
Smoking in the same room where the child stays, n (%)	**No**	28 (77.8)	36 (100)	[d]**0.003****
	Yes	8 (22.2)	0 (0)	
Mother's education, n (%)	**Illiterate**	8 (22.2)	4 (11.1)	[c]**0.328**
	Literate	1 (2.8)	2 (5.6)	
	Primary school	10 (27.8)	10 (27.8)	
	Middle school	11 (30.6)	7 (19.4)	
	High school	5 (13.9)	8 (22.2)	
	University	1 (2.8)	5 (13.9)	
Father's education, n (%)	**Illiterate**	5 (13.9)	2 (5.6)	[c]**0.398**
	Literate	1 (2.8)	0 (0)	
	Primary school	12 (33.3)	11 (30.6)	
	Middle school	10 (27.8)	9 (25)	
	High school	6 (16.7)	7 (19.4)	
	University	2 (5.6)	7 (19.4)	
Mother's occupation, n (%)	**Worker**	9 (25)	1 (2.8)	[c]**0.014***
	Unemployed	27 (75)	34 (94.4)	
	Government official	0 (0)	1 (2.8)	
Father's occupation, n (%)	**Shopkeeper**	1 (2.8)	1 (2.8)	[c]**0.053**
	Worker	35 (97.2)	29 (80.6)	
	Unemployed	0 (0)	4 (11.1)	
	Government official	0 (0)	2 (5.6)	
Heating system of the house, n (%)	**Coal stove**	1 (2.8)	0 (0)	[d]**1.000**
	Natural gas	35 (97.2)	36 (100)	

[a]Mann-Whitney U test, [b]Pearson chi-square test, [c]Fisher-Freeman-Halton test, [d]Fisher's exact test
**p<0,01

tract diseases and decrease the lung capacity of children (9-12).

This cross-sectional study evaluating the exposure of children to cigarette smoke found that in 5.6% of the cigarette smoking houses, the mother is the smoker, in 69.4% the father is the smoker; in 11.1% both parents are smokers; and in 13.9% another household member is the smoker. Research by Gursoy et al. (13) in 2008 showed that even though parents are aware of the harmful effects of passive cigarette smoking, their children are still exposed to cigarette smoke. Zafar Ullah et al. (14) showed that 55% of households have at least one active smoker,

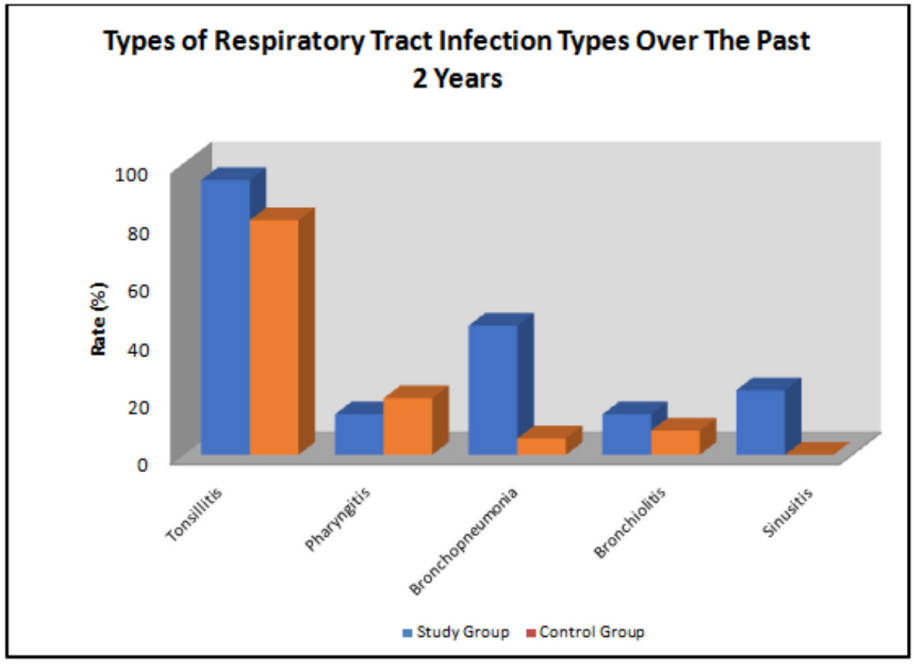

Figure 3. Distribution of types of respiratory tract infections over the past 2 years

Table 3. Comparison of the groups based on personal history and respiratory tract infections over the past two years

		Study group (n=36)	Control group (n=36)	p-value
Personal history of respiratory infection, n (%)	**No**	9 (25.0)	20 (55.6)	[b]**0.008****
	Yes	27 (75.0)	16 (44.4)	
Personal history of chronic disease, n (%)	**No**	32 (88.9)	31 (86.1)	[d]**1.000**
	Yes	4 (11.1)	5 (13.9)	
Family history of chronic disease, n (%)	**No**	35 (97.2)	35 (97.2)	[d]**1.000**
	Yes	1 (2.8)	1 (2.8)	
Number of respiratory tract infections in the past 2 years, n (%)	**None**	0 (0.0)	7 (19.4)	
	1 time	4 (11.1)	10 (27.8)	
	2 times	3 (8.3)	9 (25.0)	
	3 times	7 (19.4)	1 (2.8)	
	4 times	3 (8.3)	2 (5.6)	
	≥5 times	19 (52.8)	7 (19.4)	
	Average ± standard deviation	4.42±2.22	2.36±2.52	[a]**0.001****
Respiratory tract infections that were seen, n (%)	**Tonsillitis**	34 (94.4)	29 (80.6)	[c]**0.151**
	Pharyngitis	5 (13.9)	7 (19.4)	[b]**0.527**
	Bronchopneumonia	16 (44.4)	2 (5.6)	[b]**0.001****
	Bronchiolitis	5 (13.9)	3 (8.3)	[c]**0.710**
	Sinusitis	8 (22.2)	0	[d]**0.005****

[a]Mann-Whitney U test, [b]Pearson chi-square test, [c]Fisher-Freeman-Halton test, [d]Fisher's exact test
**p<0.01

and of those, 30% smoke when a child is present. Liao et al. (15) showed that two-thirds of parents smoke in a room where their child is at home. A study conducted in China showed that 48.3% of children are exposed to passive cigarette smoke and 76.5% of cigarette smokers smoke next to their children (16). In our study, the rate of smoking when a child was found to be 11.1%.

Recent studies show that while determining passive smoking in children, quantitative data such as cotinine levels must also be evaluated together with the information provided by the family. In our study, cigarette exposure based on urine cotinine levels was found to be 55.6%. Studies in Turkey show that passive cigarette smoking in children based on cotinine levels ranges approximately 53-92% (3,4).

Several studies show that the information provided by families on cigarette smoke exposure does not correlate with measured cotinine levels; therefore, the information by parents alone is not enough to determine the presence of exposure (17,18). Karadag et al. (19) point out that the answers to the survey conducted on parents of children who came in with an asthma attack were incoherent with the cotinine levels of the urine samples of these children; therefore, the information provided by families about cigarette exposure cannot be reliable. The study by Kahvecioğlu et al. (20) shows that 25% of children whose parents claimed that they did not smoke were exposed to cigarette smoke. This shows that parents are not objective when reporting data on cigarette smoking and explained these results by saying that children were exposed to cigarette smoke outside the house (20). In our study, based on urine cotinine levels, 52.8% of smoking parents' children were positive for passive smoking, and 58.3% of non-smoking parents' children were passive smokers as well. Therefore, even though it is not statistically meaningful, the fact that the passive smoking rate in children whose parents claim that they do not smoke is high, we believe that the answers provided by families do not reflect the truth. This study verifies that to show passive cigarette smoking, the survey method alone is not sufficient.

When the relationship between the education level of the parents and cigarette smoking is considered, it is shown that with a higher mother's education, the percentage of cigarette smoking increases; with a higher father's education, the percentage of cigarette smoking decreases (21). Karakoç et al. (22) showed that 60.5% of smoking mothers and 81.2% of smoking fathers are middle school graduates. The study by Kahvecioğlu et al. (20) showed that 63% of smoking mothers are primary school graduates, and there was no relationship found between the education levels of mothers and the frequency of smoking. Floyd et al. (23) showed that the higher the education level, the lower the cigarette smoking frequency. In another study conducted in France, it was reported that as the education level increases, so does the cigarette smoking frequency (24). In our study, 30.6% of smoking mothers were middle school graduates, and 33.3% of fathers were primary school graduates. In our study, there was no significant difference between the groups when education status and cigarette smoking were compared. Our study also showed that working mothers' being smokers was found to be statistically meaningfully higher.

A study by Arvas et al. (25) states that children with a smoker in the household get lower respiratory system infections more frequently than children with non-smokers in the house. Another study by Habesoglu et al. (26) found that mucociliary clearance is decreased in children with cigarette smoke exposure. Moreover, cigarette exposure causes hyperplasia in goblet cells, mucus hypersecretion, and dysfunction in phagocytic antibacterial defense, facilitating viral infections and causing Eustachian tube dysfunction by causing adenoid hypertrophy (26). According to a study by Uyan et al. (27), cigarette smoke exposure is highly effective in the recurrence of respiratory symptoms. Another study showed a positive relationship between the mother's being a smoker and the number of cigarettes smoked and the frequency of lower respiratory tract infections (28). A study on passive cigarette smoking and otitis media infections showed that the effect of passive smoking is mostly seen in the first year of life (29). A study by Cook et al. (30) showed that a mother's being a smoker is more effective in the first three years of life compared to a father's being a smoker and that

Table 4. Evaluation of passive cigarette smoking based on urine cotinine levels

		n (%)
Urine cotinine (ng/mL)	**Not effected (<10 ng/mL)**	32 (44.4)
	Passive smoker (10-500 ng/mL)	40 (55.6)

Table 5. Evaluation of urine cotinine and cotinine/creatinine levels

		Study Group	Control Group	p-value
Urine cotinine (ng/mL)	Median (Min.-Max.)	20.94 (0-491.16)	16.62 (0-121.7)	[a]**0.646**
Urine cotinine/creatinine (ng/mg)	Median (Min.-Max.)	0.476 (0-17.565)	0.20 (0-4.11)	[a]**0.439**

[a]Mann-Whitney U test, [b]Pearson chi-square test, Min.: Minimum, Max.: Maximum

hospitalization due to lower respiratory tract infections is three times higher in this population. An extensive study in the United States of America and Canada showed that in children 8-11 years old, upper respiratory tract infection is seen 1.7 times higher in children with a smoking parent (31). Groneberg-Kloft et al. (32) showed in their compilation that passive cigarette exposure increases respiratory illnesses and symptoms, and this is seen more obviously in the pre-school years. Our study also found that the frequency of respiratory tract infections in the last two years is statistically meaningfully higher in children who are exposed to cigarette smoke. When the two groups were compared on the basis of the type of infection, tonsillitis, pharyngitis, and bronchiolitis were similar in both groups, whereas bronchopneumonia and sinusitis were statistically meaningfully higher in children who were exposed to cigarette smoke.

Saliva, serum, and urine cotinine levels are the most widely accepted biological markers to evaluate passive cigarette exposure. Cotinine is the major metabolite of nicotine and has a higher half-life compared to other metabolites (22). In our study, the cut-off value of urine cotinine level was set at 10 ng/mL. A study by Ekerbiçer et al. (33) also accepted the cut-off value as 10 ng/mL, and 92.2% of those in the passive cigarette exposure group had urine cotinine levels higher than 10 ng/mL. In our study, based on a 10 ng/mL cut-off value, 52.8% of those with cigarette exposure and 58.3% of those with no cigarette exposure had urine cotinine levels higher than 10 ng/mL. Our study found that the most specific and sensitive cut-off value is 16.62 ng/mL. The mean cotinine level in the study group was found to be 20.94 ng/mL. The study by Boyaci et al. (21) showed that the mean cotinine level of the group with passive cigarette exposure was found to be 58 ng/mL (3), whereas the study by Arvas et al. (25) found the mean value to be 37.5 ng/mL.

The study by Puig et al. (34) found that urine cotinine levels in children with a smoking mother were significantly higher. They state that the reason behind this increase is that children spend most of their time with their mothers during pre-school ages. The study by Arvas et al. (25) compared those with smokers' mothers and other groups and found no significant difference. Yilmaz et al. (35) showed that urine cotinine levels in babies with smoking mothers are statistically meaningfully higher than in babies with non-smoking mothers. Our study also compared the smoking mothers' children with others and found no meaningful difference in urine cotinine levels. However, our study had only 6 children with a smoking mother.

The study in children between the ages of 2-5 by İnci et al. (36) found no significant difference in the urine cotinine levels of children who were exposed to cigarettes and unexposed. They reported a difference in the urine cotinine/creatinine ratios and stated that in children who could not provide a 24-hour urine sample, cotinine/creatinine ratios are more reliable compared to urine cotinine levels (36). A study with 609 children who had acute bronchiolitis and healthy controls found urine cotinine/creatinine ratios to be higher in children with bronchiolitis (37). Our study showed using the survey method that when urine cotinine levels of children with passive cigarette exposure and children without any exposure were compared, even though it was not meaningful, the cotinine levels of those who were exposed were higher. Urine cotinine/creatinine ratios were also higher in the study group, but the difference was not statistically meaningful. These results contradict the information that urine cotinine/creatinine ratios are more reliable than cotinine levels in cases where 24-hour urine samples cannot be collected.

Study Limitations

The most important limitation of our study was that the number of samples gathered was not high due to families refusing to attend the survey because it is hard to take urine samples from children. The lack of a significant difference in urine cotinine levels between the study and control groups indicates that families were hesitant to provide accurate smoking information.Passive smoking is high in those who are not exposed to cigarette smoke based on cotinine levels, implying that families were secretive about smoking and did not care if the child was exposed to cigarette smoke outside the house.Despite the limitations of our study, we think that we have contributed to the current literature since there are not many studies on passive smoking exposure in children.

Conclusion

Passive cigarette exposure is a current health problem because of its preventability and danger. Our study evaluated cigarette exposure in the house both by survey and measurement of urine cotinine levels. Our study supports the literature on the insufficiency of answers by parents alone in determining cigarette smoke exposure by showing the difference between urine cotinine levels and the survey answers.

In our study, the history of respiratory tract infection in children with cigarette smoke exposure was statistically meaningfully higher. Frequent respiratory tract infections and hospitalizations can be prevented by informing families and creating a smoke-free environment for children. To create a healthy society, raising awareness of the importance of quitting smoking is critical.

It is mandatory to provide children with an environment free of cigarette smoke. Further legal precautions must be

taken, further laboratory techniques must be developed and used to determine the problems, and all health professionals working with children must inform the public about the dangers of passive smoking.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Istanbul Bagcilar Training and Research Hospital Clinical Studies Ethical Board on September 11th, 2020, with the number 2020.09.2.07.124.

Informed Consent: A written consent form was obtained from all the families.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: S.A., M.E., Design: S.A., M.E., A.O., Data Collection and/or Processing: S.A., M.E., O.B.G., S.M.I., Analysis and/or Interpretation: S.A., M.E., O.B.G., O.B., Literature Research: S.A., M.E., O.B., S.M.I., Writing: S.A., M.E., S.M.I., O.B., A.O.

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