The Effects of Secondhand Smoke Exposure on Infant Growth: a Prospective Cohort Study

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Abstract- Mother's and infant exposure to cigarette smoke is one of the most important public health problems. There is no study in Iran evaluating the impact of cigarette smoke on infant growth and development. The purpose of this study was to determine the effects of cigarette. This prospective cohort study was conducted on 51 cigarette smoke-exposed infants (exposed group) and 51 non-exposed infants (non-exposed group). They were evaluated for weight, height and head circumference three times; five to seven days, two months and four months after birth. Urine samples were also collected in each turn. Exposure to secondhand smoke was assessed through questionnaires and urinary cotinine levels. The analysis was performed using an independent t-test, Mann-Whitney U test, *chi*-square and Fisher's exact and Kappa tests. Mean urinary cotinine level in the exposed group was 38.57±2.85 ng/mg creatinine at baseline, 86.95±1.16 at two months and 63.32±2.08 at four months of age. These indicated a gradual reduction of exposure from two to four months. The weight and height of the exposed group were significantly lower than the non-exposed group (P<0.001) at two and four months after birth. The results of the present study showed that the exposure to secondhand smoke during infancy may lead to weight and height growth reduction in the first four months of life.

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Keywords: Secondhand Smoke Exposure; Infant; Growth; Cotinine

Introduction

Based on researches and WHO's reports Regular smokers is a person who has recently or will consume more than one cigarette per day. (1) Smoking at home, work or in public places puts others at risk of exposure to Second Hand Smoke (SHS) (2). According to World Health Organization reports, inhaled smoke has threatened the health of 700 million children worldwide (3). Based on recent studies 24.3% of men and 2.9% of women are daily smokers. Although this amount has not changed in the past two decades, considering population growth, the complications of tobacco smoke exposure will increase in the future (4). Second-hand smoke exposure is present in 41.7% of homes and 50.6% of areas outside the home in Iran (5).

Tobacco smoke exposure is evaluated by different methods, such as self-reported questionnaires and cotinine level measurements (6). The questionnaire used can be considered as a valid and accurate tool to evaluate exposure to passive smoking. However, many studies showed that the self-reported exposure can be very accurate and reliable. A few researchers have shown that self-reported exposure to smoke is much lower than the real exposure. They concluded that in studies in which cigarette smoke exposure in pregnant women is evaluated by questionnaire, a large portion of women exposed to secondhand smoke are classified as

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non-exposed (5). Cotinine is a major metabolite of nicotine and has been shown to have longer half-life than nicotine (7). Cotinine could be measured in different parts of the infants' body such as hair, saliva, plasma and urine (8); however, urinary cotinine is preferred as it has longer half-life and is easier to sample. The urine's cotinine concentration is about 5 to 6 times more than serum. In addition, the urinary cotinine to creatinine ratio could help to limit the dilution effect of urine samples within different subjects (9).

Different studies have reported the effects of cigarette smoke exposure on infant growth. Increased weight gain after birth, reduction in growth and no growth change after exposure are findings shown by different studies (10-21). For example Berlanga ET. Al. also showed that exposure to cigarette smoke may reduce height growth (8) or Kanellopoulos ET. Al. reported the negative impacts of smoke exposure on head circumference growth (17). Previous studies focused mainly on the effects of maternal smoking on the infants' growth. In addition, evaluation was done by questionnaires and exposure was not measured through biomarkers. There is no investigation evaluating the impacts of SHS on infant growth factors in Iran. The aim of this study was to assess the impacts of secondhand smoke (SHS) exposure on infants' anthropometric (weight, height and head circumference) growth.

Materials and Methods

This was a prospective cohort study conducted from July 2009 to February 2010, in which 51 exposed infants with daily exposure to SHS at home, and 51 non-exposed infants were selected by systematic random sampling from health centers in southern Tehran. All infants who were referred for screening thyroid elected and qualified health center were enrolled in the study that they were aged 3-5 days. The exposed group included non-smokers who were exposed to a person with regular (daily) smoking at home with them (1,14). Infants with healthy mothers without medical problem or disease affecting the breastfeeding and without any medication were included in the study. Parents of infant or other family members in the exposed group should not use any material other than cigarette, infants should be resulted from singleton pregnancy with Apgar score more than seven at five minutes after birth, Because the measurements based on information related to the hospital apgar newborn registration certificate Therefore on all infants in both groups of single method was used and the amount of error in information for all equally assessed. All infants have breastfeeding, and have normal height, weight and head circumference at the birth time. Infants with chronic diseases, formula feeding as the sole source of food, the mothers' breast disease and the household smoker decision for smoking cessation were excluded from the study. Written consents were obtained from all the parents after detailed explanation. The Ethics Committee of Tehran University of Medical Sciences approved the study protocol. Sociodemographic characteristics and mothers' cigarette smoke exposure during and after pregnancy were obtained employing the exposure to cigarettes questionnaire by interview. The nutrition condition was evaluated by the food recall questionnaire (22).

Infant SHS exposure

Parental reports

Infant SHS exposure was evaluated by a nurse blinded to the subjects' exposure status by interview through parents' reports of the number of cigarettes smoked in the presence of their infants and other items of study's questionnaire (based on WHO's report) at 3-5 days (baseline), 2 months, and 4 months after birth in our selected health center.

Infant urinary cotinine

Urine samples were collected in late morning in standard urine bag for infants at 3-5 days, two months, and four months after birth and kept at -20°C until assay in our selected health center and were then transferred to Tarbiat Modares University. Cotinine concentrations was measured using ELISA kits (solid phase competitive immunoassay) and was reported as ng/ml. To correct the dilutional effect of urine, the cotinine level was calculated and reported based on urinary creatinine level. The cotinine in the urine was adjusted for creatinine to overcome dilution effects (9). According to previous studies cotinine levels between 11-30 ng and ml in the blood compartment has been represented the exposure to environmental tobacco smoke (9). This amount in urine has been different in different studies and according to the manner of making measurements it is different. In a previous study in Iran, exposure levels in the urine of infants under 1 year based on the statistical correlation of 27 ng mg creatinine is obtained (6). In this study based on the statistical correlation between self-report and the value of cotinine in the urine with 100% sensitivity and 88% specificity cotinine level higher than 15 ng/mg

(cotinine/creatinine) was considered positive exposure.

Measuring outcomes

Study outcomes including weight (g), height (cm) and head circumference (cm) were evaluated by a nurse blinded to the subjects' exposure status at baseline, 2 months, and 4 months of age that concurrent with vaccination time and infants automatically was driven to health center with standard meter and weight scale in our selected health center.

Statistics

Urinary cotinine distribution was not normal, so the logarithm of measurement was calculated. Changes in weight, height and head circumference of the infants were evaluated using an independent t-test and Mann-Whitney U test. The agreement between parental reports and urinary cotinine levels was assessed using the Kappa test. *P*-values less than 0.05 were considered as significant. The SPSS software V.16 performed data analysis for Windows.

Results

Baseline characteristics

There were 51 infants in each group with male to female ratio 19/32 in both groups and the mean age of 4.7±0.97 days in the exposed and 4.7±1.03 in the non-exposed group. At 2 months after birth, nine subjects (8 from the non-exposed and 1 from the exposed group not want to continue or change their health center) and at 4 months after birth, eight subjects (3 from the non-exposed and 5 from the exposed group immigrated or not want to continue or change their health center) were excluded from the study. Other infants were followed completely until four months after birth and included in the final analysis.

There were no significant differences in age, gender, weight, height, and head circumference and type of feeding (exclusively breast feeding or mixed with formula) between the two groups at baseline. Also, the maternal and paternal age, paternal education, parental Body Mass Index (BMI), family income, family size and maternal nutrition were not significantly different between the two groups. However, mothers of the non-exposed group had higher educational level (*P*=0.015) and were more employed (*P*=0.001) (Table 1). From the 51 exposed infants, 46 (90.2%) were exposed to their fathers' smoking and five (9.8%) were exposed to others' smoking; none of them had smoker mothers. The median number of daily cigarettes consumption in the presence of infants as reported by their parents was 10 (ranged from 2-40).

Table 1. Baseline and socio-demographic characteristics of study participants

Variable	Exposed (n=51)	Non-exposed(n=51)	*P* - value
Gender (female)	32 (62.7%)	32 (62.7%)	1
Infant age (mean±SD, day)	4.74 ±0.97	4.74±1.03	1
Maternal age (mean±SD, year)	26.07± 3.5	27.03± 3.5	0.717
Paternal age (mean±SD, year)	31.05± 5.5	32.05± 4.6	0.144
Mothers' education (mean±SD, year)	10.8 3.1	9.3± 3.1	0.015
Fathers' education (mean±SD, year)	10.5± 3.6	9.4± 2.7	0.079
Parity number	1.6± 0.6	1.8± 0.6	0.239
Mothers' outside employment, n (%)	0 (0%)	11 (21.6%)	<0.001
Mothers' BMI (kg/m^2)			
19-24.9	7 (13.7%)	10 (19.6%)	0.425
25-29.9	44 (86.3%)	41 (80.4%)	
Fahters' BMI (kg/m^2)			
19-24.9	36 (70.58%)	33 (64.7%)	0.525
25-29.9	15 (29.42%)	18 (35.3%)	
Fathers' occupation			
Skilled non-manual	4 (7.8%)	2 (3.9%)	
Skilled mannual	1 (2%)	1 (2%)	0.869
Semi skilled	38 (74.5%)	40 (78.4%)	
Unskilled	8 (15.7%)	8 (15.7%)	
Crowding index			
<1 person	22 (43.1%)	21 (41.2%)	
1 person	25 (49%)	28 (54.9%)	0.651
>1 person	4 (7.8%)	2 (3.9%)	
Family income (n (%), not enough)	12 (23.5%)	7 (13.7%)	0.204

Urinary cotinine levels were 38.575± 2.7 ng/mg creatinine and 7.25±2.7 ng/mg at 3-5 days after birth, 86.95± 2.61 and 6.10±3.06 at two months after birth and 63.32 ±2.18 and 6.17±2.64 ng/mg at four months after birth in the exposed and non-exposed groups, respectively (Figure 1). There was a significant difference between the two groups in terms of cotinine levels at all three evaluation intervals (P<0.001). The agreement between parental reports and urinary cotinine levels, using Kappa statistics, was 0.87 at 3-5 days, 0.79 at two months and 0.97 at four months of age. In this study, exposure was reduced from 2 months to 4 months, and this could be attributed to increasing the incentive for people to avoid the side effects of cigarette smoke. Indicating a more active participation in the study.

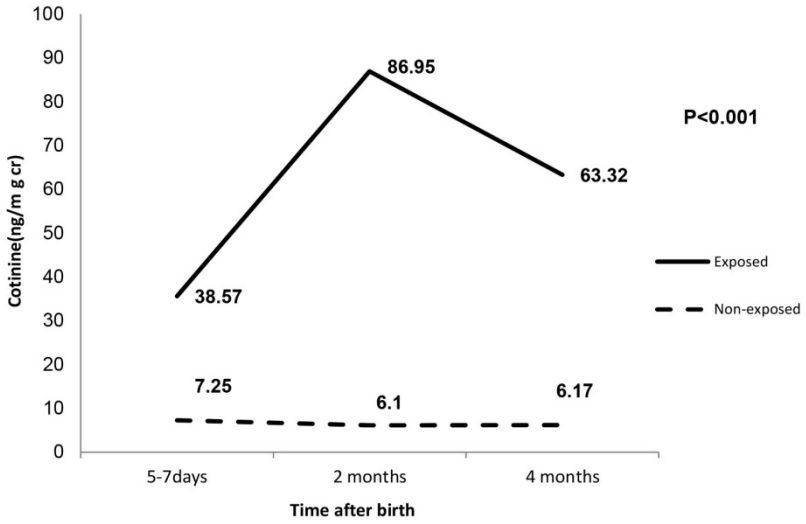

Figure 1. Cotinine to creatinine level in exposed and non-exposed group

Weight

Based on urinary cotinine levels, the exposed group had lower weight than the non-exposed group at two months (5258.82±233.6 vs. 5592.1±216.4 gr, P<0.001) and four months after birth (5383.4±272.8 vs. 5730.3±280.7 gr, P<0.001). In addition, the non-exposed group had significantly more weight gain from 3-5 days to two and four months of age (P<0.001). Weight gain during the two to four months after birth interval did not differ significantly between the two groups (Tables 2 and 3).

Table 2. Growth indices at baseline, second and fourth months after birth in exposed and non-exposed groups

Variable	Exposed (cotinine≥15 ng/mg cr)	Non-exposed (cotinine<15ng/mg cr)	p value
Weight (mean±SD, g)			
3-5 days	3208± 270.5	3150± 310.9	0.32
2nd month	5258± 233.6	5592± 216.4	<0.001
4th month	5383.4± 272.8	5730± 280.7	<0.001
Height (median, cm)			
3-5 days	51 (50-52)	50 (49-51)	0.159
2nd month	58 (58-59)	59 (58-59)	0.073
4th month	60 (60-62)	61 (60-62)	0.001
Head circumference (median, cm)			
3-5 days	34 (34-35)	34 (34-35)	0.66
2nd month	39 (38-40)	39 (39-41)	0.63
4th month	41 (41-42)	41 (41-42)	0.83

Height

Median height of infants in both groups were similar at baseline, but the non-exposed infants were taller than the exposed at four months after birth

(p<0.001). Furthermore, height growth of the non-exposed infants was more than another group from 3-5 days to two months after birth (*P*=0.04) and also from 3-5 days to four months of age (*P*=0.008). Increase in height was not significantly different between the two groups during the two to four month's interval (Tables 2 and 3).

Head circumference

The median head circumferences of the infants in both groups were 34 cm at baseline. Head circumference was not significantly different between the two groups at 2 and 4 months of age. Moreover, the increase of head circumference was not significantly different between the two groups from 3-5 days to 2 months, 3-5 days to 4 months and 2 to 4 months after birth (Tables 2 and 3).

Table 3. Infants growth after birth in exposed and non-exposed groups

variable	Exposed (cotinine≥ 15 ng/mg)	Non-exposed (cotinine< 15 ng/mg)	p value
Baseline to 2nd month	2004.4± 363.2	2403.3.4± 389.9	<0.001
Baseline to 4th month	2059.2± 363.2	2402.2± 369.8	<0.001
Height increase (median, cm)			
Baseline to 2nd month	7 (6-9)	8 (7-10)	0.04
Baseline to 4th month	10 (8-10)	11 (8-12)	0.008
Head circumference increase (median, cm)			
Baseline to 2nd month	4 (3-6)	5 (4-6)	0.41
Baseline to 4th month	6 (6-7)	7 (6-7)	0.52

Weight difference (mean±SD, g)

Discussion

This was the first study in Iran evaluating the growth of infants exposed to SHS based on urinary cotinine levels not only with questionnaire. The results showed that exposed infants had lower weight at 2 and 4 months after birth, and lower height at 4 months after birth. In addition, they had less weight and height growth from 3-5 days to 2 and 4 months after birth. Increase in weight, height and head circumference did not differ significantly between the two groups during the 2 to 4 months interval.

Consistent with results of previous studies conducted in 2009 which showed infants exposed to SHS have less weight in the first six months and less weight gain in the first three months of life (11,12), weight gain in the exposed infants was found to be significantly lower than the non-exposed infants in the present study. Hypoxia resulting from exposure to cigarette smoke may cause changes in energy metabolism (23) and ultimately cause reduced weight gain. The nicotine in cigarette smoke could reduce appetite. Thus, if the exposed infants are prevented from SHS exposure, they would have greater demand for food which will result in obesity (25). Vilwerth *et al*., showed that infants of mothers who are heavy smokers, have accelerated growth after birth, but if the mothers reduce their smoking during pregnancy their infants will have less growth speed during the first six months of life compared to others (11). The growth of infants is affected by smoke dose; infants of heavy smoker parents have more weight gain than non-smokers' infants, but the infants of light smokers have less weight gain (26,27)

Based on the results of the present study, exposed infants' height growth was less than the non-exposed. Berlanga *et al*., also showed that exposure to cigarette smoke may reduce height growth (8). Furthermore, Fenercioghloo *et al*., reported less height growth during the first three and six months of life in infants exposed to cigarette smoke in comparison with other infants (12); consistent with the findings of the present study. Lower height growth in infants exposed to cigarette smoke may be due to the cadmium in cigarette smoke. This cadmium disturbs the balance of cadmium-zinc and cadmium-calcium in the body resulting in bone loss and reduced height growth (8).

Association of head circumference growth with future IQ and psychological and behavioral disorders have been demonstrated (12,27). On the basis of our findings, the head circumference was shown not to have a significant difference between the two groups. There is controversy surrounding the effects of cigarette smoke exposure on head circumference of infants. Yilmaz *et al*., and Kanellopoulos *et al*., reported the negative impacts of smoke exposure on head circumference growth (17,28) but Ong *et al*., did not confirm these effects (10) this was the first investigation in Iran in which SHS exposure was assessed based on urinary cotinine levels. All three indicators of infant growth were evaluated simultaneously. Short-term followup of subjects could be considered as a limitation of the present study.

Based on these results, exposure to SHS has adverse effects on height and weight increase during the first four months of life. These effects emphasize the importance of enforcing a complete smoking ban in the presence of infants.

In a study of infant's growth especially in the early stages, control of confounding factors is important. This study matched the infants in the two groups with two solutions matched or deletes an infant that could minimize the impact of these factors.

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