The Egyptian Journal of Bronchology

RESEARCH

Open Access

The impact of secondhand smoke exposure on the pregnancy outcome: a prospective cohort study among Egyptian community

Eman Sobh[1*†], Asmaa Mahmoud Mohammed[2†], Zeinab Adawy[1], Aziza Hussein Nassef[3] and Adel Hasheesh[4]

Abstract

Background: Secondhand smoke (SHS) exposure gained lesser interest than active smoking. There is evidence from previous studies that SHS exposure had negative effects on fetal growth. This study aimed to examine the effect of smoke exposure on pregnancy outcome and to evaluate the level of nicotine urinary end-product cotinine in pregnant women in the late trimester. We included 36 women with a history of SHS exposure and 48 women without a history of exposure; all were in last trimester of pregnancy. We measured cotinine level in urine and followed the two groups until delivery and recorded fetal outcomes. Fetal biophysical parameters and blood flow waveforms were measured using B-mode and Doppler ultrasonography, respectively.

Results: The total range of the urinary cotinine creatinine ratio (CCR) concentration in the SHS exposed pregnant women was 0.01–0.2, IQR = 0.18 ng/mg.cr, versus 0.01–0.1, and IQR = 0.03 ng/mg.cr in the non-exposed group. The mean value as well as the mean rank of CCR was significantly higher (0.1 ± 0.08 ng/mg.cr., 40.3 respectively) in the exposed pregnant women as compared to the non-exposed pregnant women ((0.04 ± 0.02), 29.3 respectively, p value < 0.05). Newborn of the exposed women had significantly low birth weight which negatively correlated with cotinine level and had a dose-response relationship.

Conclusions: SHS exposure had negative effects on fetal outcomes. Efforts should be utilized to increase awareness of the consequences of secondhand smoke on the fetus and strict follow-up of exposed women for early detection.

Keywords: Cotinine, Environmental tobacco smoke, Low birth weight, Pregnancy outcome, Secondhand smoke exposure

Background

Tobacco smoking has been proven to be harmful and has a teratogenic effect on the fetus [1]. Maternal smoking during pregnancy is an important global health problem resulting in several fetal adverse effects [2]. Secondhand smoke (SHS) is a mixture of the smoke formed from the combustion of tobacco products and smoke exhaled by smokers [3, 4]. Secondhand smoke exposure is classified as a human carcinogen [3] and is a leading cause of mortality and morbidity [5]. The World Health Organization report states that in Egypt, 50% of people are exposed to secondhand smoke in their own homes [6]. Pre-pregnancy and pregnancy tobacco exposure to cigarette smoke has a deleterious effect on the mother and the fetus [7]. These harmful effects include infertility [8], ectopic pregnancy [9], stillbirth [10], placental abnormalities [11–14], intrauterine growth retardation [15], preterm delivery [16], and low birth weight [17]. Recent systematic review and meta-analysis reported association between maternal exposure to smoking and discontinuation of breastfeeding in the first 6 months, which may be explained by the inhibitory effect of nicotine and other

*Correspondence: emansobh2012@Gmail.com; emansobh@azhar.edu.eg
†Eman Sobh and Asmaa Mahmoud Mohammed are joint first author.
[1] Chest Diseases Department, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt
Full list of author information is available at the end of the article

chemicals present in tobacco smoke on prolactin release [18]. There are several biomarkers of SHS exposure: thiocyanate and nicotine and cotinine, a nicotine metabolite (in plasma, saliva, urine, or hair) is specific for SHS exposure [3]. This work aims to study the effect of smoke exposure on pregnancy outcome and to evaluate the level of nicotine urinary end-product cotinine in pregnant females in the late trimester.

Methods

This prospective cohort study was done during the period from March 2019 to March 2020 in the University Hospital, Cairo, Egypt. We included pregnant women during the last trimester. We recorded demographic data, smoke exposure, and gestational age. We also recorded the outcome of pregnancy. Maternal age, gravidity, menstrual age at the time of the scan, gender, ethnicity, and presence of obstetric complications were also documented. We included two groups: the first group included pregnant women in the last trimester nonsmokers with second -hand smoke exposure at home because of husband or other housemates. The second group included nonsmoker pregnant women during the last trimester not exposed to secondhand smoke. Secondhand smoke exposure was defined as exposure to smoke from combustible tobacco products at home, work, or public places [19].

Those who had inaccurate obstetric history regarding the last menstrual period, pre-pregnancy birth weight, or had diabetes, heart disease, renal disease, twin pregnancy, or known fetal congenital anomalies were excluded from the study. Also, non-Egyptian women were excluded to avoid the effect of ethnicity on birth weight.

Data management

Data were collected by the research team during the interview and included the following: age, residence, education level, occupation, pre-pregnancy and obstetric comorbidities, last menstrual period, expected date of delivery, smoke exposure at home, and work. Pregnant women's weight, height, and weight gain were also recorded.

- The mean arterial blood pressure (MAP) of the participants was calculated using the formula, MAP = ([(2 × diastolic) + systolic]/3) [20].
- Obstetric ultrasonography was done at the first visit (routine antenatal care) and end of pregnancy. All ultrasound examinations were performed by a single obstetrician who is experienced in ultrasonography. We used two-dimensional ultrasonography to scan each fetus once and measured standard fetal biometric parameters {biparietal diameter (BPD), head circumference (HC), AC, humeral diaphysis length (HDL) and femoral diaphysis length (FDL)}, in addition to fetal weights which were estimated using AC and FDL and BPD, AC, and FDL models [21].

Measurement of serum cotinine level

Morning urine samples of the participants were collected in sterile containers and were preserved at − 20 °C. The following investigations have been performed:

- The concentration of cotinine in the urine was determined by enzyme-linked immunosorbent assay (ELISA), a colorimetric method, using A commercial cotinine Elisa kits (Abnova, Taiwan). The detection limit was 1 ng/ml.
- The creatinine concentration in urine was determined by colorimetric, alkaline picrate method (Jaffe) [22], using commercially used creatinine (urine) colorimetric assay kit (Cayman, USA). Technique was performed according to manufacturer's guidelines.
- Correction of cotinine concentration for creatinine excretion (CCR) [23].

Statistical analysis

The collected data were analyzed using IBM SPSS software version 20.0. The quantitative variables were expressed as mean ± SD, ranges, and the differences between the two groups were compared using unpaired Student t test for the normally distributed data and Mann-Whitney U test for the skewed variables. The qualitative variables were expressed as frequencies and compared using χ^2 test. Differences were considered significant with P value ≤ 0.05. Logistic regression analysis was performed to test the association between the exposure and the outcome after adjusting the covariates. The linear regression model was done to predict the adverse effects related to exposure.

Results

Demographic and clinical data

Clinical data from 84 pregnant women were collected; of them, 36 pregnant women had reported SHS exposure because of husband or other housemates. Another 48 pregnant women did not report any exposure to tobacco smoke had been enrolled in the study. The mean age of the exposed pregnant women was significantly lower than that of the non-exposed women, 27.8 ± 6.6 with an age range 20–41 years versus 31.2 ± 6.2 with an age range 20–45 years, respectively. About one fifth of the exposed women (19.5%) were living in rural areas which is significantly higher compared to the non-exposed

women (4.2%). The two studied groups were comparable in their educational level as well as in their occupational status and the gravida number (p value> 0.05).

The exposed pregnant women reported a significant history of pre-eclampsia and bronchial asthma in previous pregnancies. Moreover, 25% of SHS exposed pregnant women had at least one child diagnosed as a case of bronchial asthma, while no cases were reported among the non-exposed mothers (Table 1).

Maternal complications and pregnancy outcome

No significant differences were observed between the two studied groups in their weight gain, mean arterial blood pressure (MAP), and heart rate (p value > 0.05). One case of each group developed preeclampsia during the current pregnancy (2.7% versus 2.1% in SHS exposed and non-exposed women respectively, p value> 0.05 (Table 1).

The likelihoods of poor pregnancy outcomes were significantly higher among the SHS exposed pregnant women compared to SHS non-exposed women. The likelihood of abortion was as follows: OR = 4.1 ((CI 1.3–13.2), p value = 0.007), IUGR (OR = 10 (CI 2–57.4), p value = 0.006, stillbirth OR = 5.7 (CI 1.0–32), p value = 0.02, fetal death OR = 10.8 (CI 2.6–44.2), p value = 0.001 among SHS exposed pregnant women. Moreover, the incidence of IUGR among the exposed pregnant women was significantly higher than its occurrence in the non-exposed by 6.6 times (CI (1.4–4.30), p value = 0.01). About one third (30.5%) of the infants born for SHS exposed mothers were admitted in intensive neonatal care units which were significantly higher than the proportion in the non-exposed group (4.1%), p value = 0.003.

Gestational data and fetal measurements

The two studied groups had no significant difference in gestational age (p value> 0.05). However, the mean fetal age and estimated fetal weight by ultrasound were significantly lower in the SHS exposed mothers than the observed in the non-exposed mothers. Moreover, the mean rank as well as the mean value of the difference between the gestational age and fetal age was significantly higher in the exposed mothers than in the non-exposed mothers (1.4 ± 1.3 weeks versus 0.5 ± 0.9 weeks respectively).

In addition, infants born for the SHS exposed mothers had significantly lower mean birth weight than the infants born to the non-exposed mothers (2989.8 ± 492.2 g versus 3421.2 ± 402.5 g respectively), p value< 0.001. On the other hand, the fetal crown rump length, head

Table 1 The antenatal profile of pregnant women exposed to secondhand smoking versus non-exposed pregnant women

Characteristics		SHS exposed women ($n = 36$)	SHS non-exposed women ($n = 48$)	p value
Age (mean ± SD)/range		27.8 ± 6.6/(20–41)	31.2 ± 6.2/ (20–45)	0.02*
Residence: no. (%): urban/rural		29 (80.5)/7 (19.5)	46 (95.8)/2 (4.2)	0.02*
Education: no. (%): illiterate/educated		16 (44.4)/20 (55.6)	18 (37.5)/30 (62.5)	0.5
Occupation: no. (%): not employed/employed		34 (94.4)/2 (5.6)	44 (91.6)/4 (8.4)	0.6
Exposure Median (range)/IQR	Duration (years):	3 (1–11)/3.5	–	–
	Exposure index[a]	380 (114–1140)/553	–	–
	Daily exposure (hours)	2 (0.75–4)/2	–	–
	Last exposure (hours)	12 (1–36)/5	–	–
Cotinine-creatinine ratio (CCR) (ng/mg.cr)	Mean ± SD	0.1 ± 0.08	0.04 ± 0.02	0.002*
	Mean rank	40.3	29.3	0.04*
	(Range)/IQR	(0.01–0.2)/0.18	0.04 (0.01–0.1)/0.03	
Gravida number		3.5 ± 2.1	3.2 ± 1.6	0.4
History of pre-eclampsia		9 (0.25)	2 (4.1)	0.005*
Current pre-eclampsia		1 (2.7)	1 (2.1)	0.8
Bronchial asthma		7 (19.4)	2 (4.1)	0.02*
Hypertension		1 (2.7)	0	0.2
CHD		1 (2.7)	0	0.2
Bronchial asthma in one child		9 (0.25)	0	< 0.001*
Weight gain (kg)		11.8 ± 5.5	11.1 ± 3.1	0.4
MAP (mm Hg)		93.6 ± 7	94.5 ± 4.2	0.4
Heart rate (beats/min)		88.6 ± 9	86.3 ± 6.6	0.1

[a] The exposure index is the product of no. of smokers in the house, average no. of cig/day in the presence of the pregnant women, the period of gestation in weeks

*Significant

Table 2 Fetal parameters of the current pregnancy outcome in PS exposed vs. non-exposed pregnant women

Variable	SHS exposed women ($n = 36$)	SHS non-exposed women ($n = 48$)	*p* value
Gestational age (weeks)	38.1 ± 0.9	38.4 ± 0.8	0.07
Fetal age (weeks)	36.7 ± 1.3	37.9 ± 1.2	< 0.0001*
GA/FA difference (weeks)	1.4 ± 1.3(52.3)[a]	0.5 ± 0.9(25.1)[a]	0.001*
Estimated fetal weight (g)	3077.9 ± 439.1	3521 ± 411.6	< 0.0001*
Birth weight (g)	2989.8 ± 492.2	3421.2 ± 402.5	< 0.0001*
Crown rump length (cm)	36.3 ± 1.5	37.7 ± 1	< 0.0001*
Head circumference (cm)	36.2 ± 1.5	37.6 ± 1.2	< 0.0001*
Abdominal circumference	36.1 ± 1.3	37.6 ± 1.1	< 0.0001*
Femur length (cm)	36.1 ± 1.6	37.8 ± 1.2	< 0.0001*
Umbilical artery pulse index	0.6 ± 0.08	0.5 ± 0.06	< 0.0001*
Amniotic fluid index	10.2 ± 3.7	12.4 ± 1.9	< 0.001*

[a] Is the mean rank of the nonparametric test

*Significance is considered at ≤ 0.05

circumference, abdominal circumference, femur length, umbilical artery pulse index, and amniotic fluid index were significantly lower in infants of the exposed mothers than in infants of the non-exposed mothers (Table 2).

Urinary cotinine and pregnancy outcome

The urinary cotinine-creatinine ratio was significantly higher in pregnant women exposed to SHS (Table 1, Fig. 1).

The linear regression model prediction of the fetal parameters significantly well based on the concentration of urinary cotinine creatinine ratio (CCR) showed a significantly negative effect. The CCR was inversely correlated with the birth weight, estimated fetal weight, crown rump length, head circumference, femur length, and the amniotic fluid index. The model predicted that each increase in CCR by 1 ng/mg.cr. was accompanied with decreases in the infant birth weight by 2.9 g, crown rump length by 0.009 cm, head circumference by 0.008 cm, abdominal circumference by 0.01 cm, femur length by 0.01 cm, and the amniotic fluid index by 0.004. Meanwhile, the CCR was directly correlated with the umbilical artery pulse index. It was predicted that each increase in the CCR by 1 ng/mg.cr was accompanied by an increase in the umbilical artery pulse index by 0.1.

Discussion

Secondhand smoke exposure was found to be associated with several obstetric complications and adverse fetal outcomes [24, 25]. We investigated the effects of SHS exposure on fetal outcomes. We also measured the level of cotinine in the urine of pregnant females. Cotinine is the primary metabolite of nicotine and the most used and reliable biomarker of nicotine exposure with a half-life between 16 and 18 h [26].

In this study, we found that secondhand smoke-exposed women were significantly younger than non-exposed women, and most of them live in rural areas (Table 1). Bachock et al. [27] reported similar results regarding age. Exposed women also had significantly higher levels of urinary cotinine creatinine ratio (Table 1). We also found that exposed pregnant women had a significantly higher history of preeclampsia, bronchial asthma, and reported asthma in at least one child than non-exposed (Table 1). Meanwhile, the likelihood of abortion, IUGR, stillbirth, and fetal death in previous pregnancies among the exposed women were significantly 4, 10.6, 5.7, and 10.8 times, respectively, than the likelihood among the non-exposed women. The incidence of IUGR in the current pregnancy among the exposed pregnant women was significantly higher than its occurrence in the non-exposed by 6.6 times with a higher incidence of admission to the NICU.

Ashford et al. found a significant increase in NICU admission in SHS exposed women, and they are 2–4 times likely to develop complications [28].

Birth weight is one of the most significant postnatal predictors of pregnancy outcome and is the main growth parameter that is routinely evaluated in newborns [29]. This study provides evidence of the harmful effects of secondhand smoke exposure. We found that the mean fetal age by ultrasound was significantly lower in exposed women than the observed in the non-exposed women with a significantly higher difference between the gestational age and fetal age.

The estimated fetal weight was significantly lower in the exposed women than in the non- exposed women. Infants born to the secondhand smoke-exposed women had significantly lower mean birth weight than those the non-exposed women. At the same time, the fetal crown rump length, head circumference, abdominal circumference, femur length, umbilical artery pulse index, and amniotic fluid index were significantly lower in infants of secondhand smoke-exposed women than in infants of the non-exposed mothers (Table 2).

The same results were reported in previous studies. In a retrospective study, Bachok et al. [27] reported that infants born to secondhand smoke-exposed women had significantly lower birth weight than non-exposed with

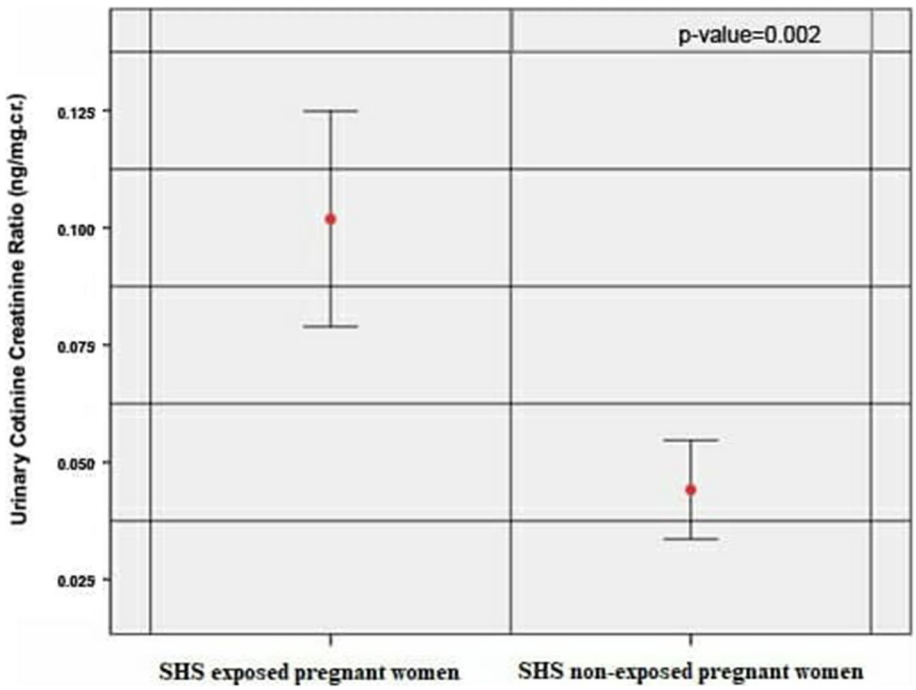

Fig. 1 Urinary cotinine creatinine ratio in the studied population: urinary cotinine creatinine ratio was significantly higher in pregnant women exposed to SHS compared to non-exposed pregnant women. The mean value as well as the mean rank of CCR was significantly higher (0.1 ± 0.08 ng/mg.cr., 40.3 respectively in the exposed pregnant women as compared to the non-exposed pregnant women (0.04 ± 0.02), 29.3 respectively, *p* value< 0.05)

a dose-response relationship. Previous studies found an association between secondhand smoke exposure and low birth weight [30, 31]. Windham et al. [32] found the risk estimate to be only a 1.2 odds ratio for this association. Another study also showed that exposed women were 1.6 times more likely to deliver LBW babies than non-exposed women [33]. A study in Saudi Arabia found that SHS exposure was associated with reduced birth weight, head circumference, and shorter length in addition to an increased rate of LBW infants [30]. On the other hand, a retrospective study done by Krishnamurthy et al. [34] reported no association between SHS exposure and low birth weight.

The mechanism behind the reduced birth weight in the exposed group may be the negative effects of nicotine on the development of the placenta and its function leading to decreased oxygen delivery to the fetus [12, 35]. This is supported by our finding of a significant increase in the umbilical artery pulse index of the SHS exposed group indicating increased fetoplacental and maternal-placental resistance [36]. Yildiz et al. [37] reported similar results. A recent study investigated the pathways responsible for the effects of maternal SHS exposure on birth weight; they reported that SHS exposure during pregnancy results in increased inflammatory mediators IL-1β, TNF-α, IL-6, and VCAM-1 which results in low birth weight directly (TNF-α) or indirectly through decreased placental weight [38].

Accurate assessment of fetal growth depends on various ultrasonographic parameters. We found that the linear regression model predicts the fetal parameters significantly depend on the concentration of urinary cotinine creatinine ratio (CCR). The CCR was inversely correlated with the birth weight, estimated fetal weight, crown rump length, head circumference, femur length, and the amniotic fluid index. The model predicted that each increase in CCR by 1 ng/mg.cr. was accompanied by decreases in the infant birth parameters indicating a dose-response relationship. Peacock study found that cotinine was closely related to birth weight in smokers [39].

This study supports the results of previous ones regarding the dangerous effects of secondhand smoke exposure on the outcome of the pregnancy and that this effect is correlated with the degree of exposure.

The discrepancies between studies regarding the association between SHS exposure and birth weight may be due to the difference in the level and duration of SHS exposure in different studies and the different ethnic groups in each study [38].

The strengths of this study are that we did not depend on pregnant self-reported exposure, but we used, in addition, the urinary cotinine as an index of secondhand smoke exposure and the cohort nature of the study. The limitation of this study is the small number of the studied group.

Conclusion

Cotinine level is significantly elevated in secondhand smoke-exposed women. Secondhand smoke exposure had a deleterious effect on the mother and fetus. Birth weight is significantly lower in infants born to women with secondhand smoke exposure. The results of this study should lead to an improvement in the public health strategy toward prevention and control of secondhand smoke exposure during pregnancy and implementation in the antenatal care program. Advice about smoking cessation and referral for smoking cessation programs are encouraged for both parents during antenatal visits.

Abbreviations

SHS: Secondhand smoke; CCR: Cotinine Creatinine ratio; MAP: The mean arterial blood pressure; BPD: Biparietal diameter; HC: Head circumference; HDL: Humeral diaphysis length; AC: Abdominal circumference; FDL: Femoral diaphysis length; IUGR: Intrauterine growth retardation; NICU: Neonatal intensive care unit; LBW: Low birth weight; IL: Interleukin; TNF: Tumor necrosis factor.

Acknowledgements

Not applicable

Authors' contributions

E.S, A.M.M, Z.A, A.H.N., and A.H. participated in the research concept, design, and literature review. E.S. Z.A, A, and N. H. participated in the clinical part of the study and participated in the data acquisition and analysis. A.M.M. and A.H performed the lab studies, did statistical tests, and analyzed the data, E.S, A. M. M., and A.H wrote the manuscript. E.S revised the manuscript critically. All authors read the manuscript and revised it and accepted the final version to be published.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All participants gave written informed consent before enrollment in the study. The study protocol has been approved by the institutional ethics review board of the Faculty of Medicine for Girls, Al-Azhar University (AFMG-IRB) (approval number 2019010170).

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Chest Diseases Department, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt. [2]Department of Environmental and Occupational Medicine, National Research Centre, Cairo, Egypt. [3]Gynecology and Obstetrics Department, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt. [4]Department of Research of Children with Special Needs, National Research Centre, Cairo, Egypt.

Received: 16 June 2021 Accepted: 6 October 2021
Published online: 06 November 2021

References

1. Rogers JM (2009) Tobacco and pregnancy. Reprod Toxicol 28(2):152–160 [cited 2020 Sep 13] Available from: https://pubmed.ncbi.nlm.nih.gov/19450949/
2. Substance use during pregnancy | CDC [Internet]. [cited 2020 Sep 13]. Available from: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/substance-abuse/substance-abuse-during-pregnancy.htm
3. ERS - Respiratory health and disease in Europe [Internet]. [cited 2020 Sep 13]. Available from: https://www.erswhitebook.org/
4. Öberg M, Jaakkola MS, Prüss-Üstün A, Schweizer C, Woodward A. Public health and the environment, Geneva European Centre for Environment and Health. Rome Tobacco Free Initiative; 2010.
5. WHO | Second-hand smoke [Internet]. [cited 2020 Sep 13]. Available from: https://www.who.int/gho/phe/secondhand_smoke/en/
6. WHO EMRO | Tobacco | Programmes | Egypt [Internet]. [cited 2020 Sep 13]. Available from: http://www.emro.who.int/egy/programmes/tobacco-free-initiative.html
7. (US) C for DC and P, (US) NC for CDP and HP, (US) O on S and H. Reproductive and developmental effects. 2010 [cited 2020 Sep 13]; Available from: https://www.ncbi.nlm.nih.gov/books/NBK53022/
8. Committee of the American Society for Reproductive Medicine P, Penzias A, Bendikson K, Butts MSCE S, Coutifaris C, Falcone T, et al. Smoking and infertility: a committee opinion. 2018 [cited 2020 Sep 13]; Available from: https://doi.org/10.1016/j.fertnstert.2018.06.016
9. Horne AW, Brown JK, Nio-Kobayashi J, Abidin HBZ, Adin ZEHA, Boswell L et al (2014) The association between smoking and ectopic pregnancy: why nicotine is BAD for your fallopian tube. PLoS One 9(2):89400 [cited 2020 Sep 13] Available from: /pmc/articles/PMC3930728/?report=abstract
10. Marufu TC, Ahankari A, Coleman T, Lewis S (2015) Maternal smoking and the risk of still birth: systematic review and meta-analysis. BMC Public Health 15(1):239 [cited 2020 Sep 13] Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-015-1552-5
11. Jauniaux E, Burton GJ (2007) Morphological and biological effects of maternal exposure to tobacco smoke on the feto-placental unit. Early Hum Dev 83:699–706 [cited 2020 Sep 13] Available from: https://pubmed.ncbi.nlm.nih.gov/17900829/
12. Zdravkovic T, Genbacev O, McMaster MT, Fisher SJ (2005) The adverse effects of maternal smoking on the human placenta: a review. Placenta 26(Suppl):81–86
13. Pintican D, Poienar AA, Strilciuc S, Mihu D (2019) Effects of maternal smoking on human placental vascularization: a systematic review. Taiwan J Obstetr Gynecol 58:454–459 Elsevier Ltd
14. Vogt Isaksen C (2004) Maternal smoking, intrauterine growth restriction, and placental apoptosis. Pediatr Dev Pathol 7(5):433–442. https://doi.org/10.1007/s10024-004-0105-1 [cited 2020 Sep 13]
15. Habek D, Habek JČ, Ivanišević M, Djelmiš J (2002) Fetal tobacco syndrome and perinatal outcome. Fetal Diagn Ther 17(6):367–371 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/12393968/
16. Fantuzzi G, Aggazzotti G, Righi E, Facchinetti F, Bertucci E, Kanitz S et al (2007) Preterm delivery and exposure to active and passive smoking during pregnancy: a case-control study from Italy. Paediatr Perinat Epidemiol 21(3):194–200 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/17439527/
17. Zheng W, Suzuki K, Tanaka T, Kohama M, Yamagata Z, Asato Y, et al (2016) Association between maternal smoking during pregnancy and low birthweight: effects by maternal age. PLoS One. 11(1). [cited 2020 Sep 13]. Available from: /pmc/articles/PMC4721610/?report=abstract

18. Suzuki D, Wariki WMV, Suto M, Yamaji N, Takemoto Y, Rahman M, et al (2019) Secondhand smoke exposure during pregnancy and mothers' subsequent breastfeeding outcomes: a systematic review and meta-analysis. Sci Rep. 9(1). [cited 2020 Sep 18]. Available from: /pmc/articles/PMC6562041/?report=abstract
19. Anna. and Second-hand smoke exposure in pregnancy. 2013.
20. Zheng L, Sun Z, Li J, Zhang R, Zhang X, Liu S et al (2008) Pulse pressure and mean arterial pressure in relation to ischemic stroke among patients with uncontrolled hypertension in rural areas of China. Stroke. 39(7):1932–1937 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/18451345/
21. Salomon LJ, Alfirevic Z, Da Silva Costa F, Deter RL, Figueras F, Ghi T et al (2019) ISUOG Practice Guidelines: ultrasound assessment of fetal biometry and growth. Ultrasound Obstet Gynecol 53(6):715–723. https://doi.org/10.1002/uog.20272 [cited 2020 Sep 14]
22. Creatinine Jaffe. Colorimetric-kinetic Store at 2-8°C.
23. Benowitz NL (1983) The use of biologic fluid samples in assessing tobacco smoke consumption. NIDA Res Monogr 48:6–26
24. Crane JMG, Keough M, Murphy P, Burrage L, Hutchens D (2011) Effects of environmental tobacco smoke on perinatal outcomes: a retrospective cohort study. BJOG 118(7):865–871
25. Kharrazi M, DeLorenze GN, Kaufman FL, Eskenazi B, Bernert JT, Graham S et al (2004) Environmental tobacco smoke and pregnancy outcome. Epidemiology. 15(6):660–670 [cited 2020 Sep 14]. Available from: https://pubmed.ncbi.nlm.nih.gov/15475714/
26. Montalto NJ, Wells WO (2007) Validation of self-reported smoking status using saliva cotinine: a rapid semiquantitative dipstick method. Cancer Epidemiol Biomark Prev 16(9):1858–1862 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/17855706/
27. Norsa'Adah B, Salinah O (2014) The effect of second-hand smoke exposure during pregnancy on the newborn weight in Malaysia. Malaysian J Med Sci 21(2):44–53 [cited 2020 Sep 13]. Available from: www.mjms.usm.my
28. Ashford KB, Hahn E, Hall L, Rayens MK, Noland M, Ferguson JE (2010) The effects of prenatal secondhand smoke exposure on preterm birth and neonatal outcomes. J Obstet Gynecol Neonatal Nurs 39(5):525–535 [cited 2020 Sep 13]. Available from: /pmc/articles/PMC2951268/?report=abstract
29. Lee W, Balasubramaniam M, Deter RL, Hassan SS, Gotsch F, Kusanovic JP et al (2009) Fetal growth parameters and birth weight: their relationship to neonatal body composition. Ultrasound Obstet Gynecol 33(4):441–446 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/19253324/
30. Wahabi HA, Alzeidan RA, Fayed AA, Mandil A, Al-Shaikh G, Esmaeil SA (2013) Effects of secondhand smoke on the birth weight of term infants and the demographic profile of Saudi exposed women. BMC Public Health 13(1):341 [cited 2020 Sep 13] Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-13-341
31. Salmasi G, Grady R, Jones J, McDonald SD (2010) Environmental tobacco smoke exposure and perinatal outcomes: a systematic review and meta-analyses. Acta Obstet Gynecol Scand 89:423–441. https://doi.org/10.3109/00016340903505748 Wiley [cited 2020 Sep 13]
32. Windham GC, Eaton A, Hopkins B (1999) Evidence for an association between environmental tobacco smoke exposure and birthweight: a meta-analysis and new data. Paediatr Perinat Epidemiol 13(1):35–57 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/9987784/
33. Khader YS, Al-Akour N, AlZubi IM, Lataifeh I (2011) The association between second hand smoke and low birth weight and preterm delivery. Matern Child Health J 15(4):453–459 [cited 2020 Sep 13] Available from: https://pubmed.ncbi.nlm.nih.gov/20364365/
34. Krishnamurthy A, Chinnakali P, Dorairajan G, Sundaram S, Sarveswaran G, Sivakumar M et al (2018) Tobacco use, exposure to second-hand smoke among pregnant women and their association with birth weight: a retrospective cohort study. J Fam Med Prim Care 7(4):728 [cited 2020 Sep 18]. Available from: /pmc/articles/PMC6131999/?report=abstract
35. Romani F, Lanzone A, Tropea A, Tiberi F, Catino S, Apa R (2011) Nicotine and cotinine affect the release of vasoactive factors by trophoblast cells and human umbilical vein endothelial cells. Placenta. 32(2):153–160
36. Baschat AA, Hecher K (2004) Fetal growth restriction due to placental disease. Semin Perinatol 28(1):67–80
37. Yildiz S, Sezer S, Boyar H, Cece H, Ziylan SZ, Vural M et al (2011) Impact of passive smoking on uterine, umbilical, and fetal middle cerebral artery blood flows. Jpn J Radiol 29(10):718–724. https://doi.org/10.1007/s11604-011-0622-6 [cited 2020 Sep 24]
38. Niu Z, Xie C, Wen X, Tian F, Yuan S, Jia D et al (2016) Potential pathways by which maternal second-hand smoke exposure during pregnancy causes full-term low birth weight. Sci Rep 6(1):1–8 [cited 2020 Sep 18]. Available from: www.nature.com/scientificreports/
39. Peacock JL, Cook DG, Carey IM, Jarvis MJ, Bryant AE, Ross Anderson H et al (1998) Maternal cotinine level during pregnancy and birthweight for gestational age. Int J Epidemiol 27(4):647–656 [cited 2020 Sep 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/9758120/

Publisher's Note