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Comparison between the Effects of Maternal Exposure to Natural Fibers and Synthetic Fibers Used In Textiles Industry on Pregnancy Outcomes

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ABSTRACT

Background: The Textile production industry is one of the most precious and most technologically complex of all industries because of the variety of substrates, processes, machinery and components used and finishing steps undertaken.

Aim of the work: To compare between the effect of maternal exposure to natural fibers and synthetic fibers used in textiles industry among women textile workers, on pregnancy outcome, at Misr Spinning and Weaving Company in El Mahalla El Kubra and Tanta, Egypt.

Patients and methods: The study deals with, comparison between the effect of maternal exposure to natural fibers and synthetic fibers used in textiles industry on pregnancy outcomes conducted in Corporation with the Egyptian Ministry of Health, at Textile factories in Al-Mahalah Al-Kubra and Tanta, during the period from February 2021 to February 2022.

Results: there is non-significant differences in mean intra-pregnancy BMI, and age between exposed and control groups. Mean duration of exposure to textile pollution in the exposed group was (8.3±0.6) years; (20 %) exposed between 2 and 6 years; (44 %) exposed between 6 and 10 years and (36%) exposed more than 10 years.

Conclusion: Pregnant women exposed to textile induced pollutions inside Misr Spinning and Weaving Company at Al Mahalla Al Kubra, at increased risk of the adverse pregnancy outcomes with a particular TLBW, preterm birth, miscarriage hypertension, and congenital anomalies. There was significant statistical difference between natural and synthetic fibers. It was also noticed that there was marked improvement in maternal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

Keywords: *Textile; pregnancy outcome; synthetic fibers; congenital anomalies; maternal exposure.*

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INTRODUCTION

Textile manufacturing is one of the world's oldest industries. It's as ancient as civilization itself, and it's becoming bigger every day. Textile goods, like food, are a basic human necessity. For developed nations, the textile chain from seed cotton to cotton-based textile and garment manufacturers is particularly important.. [1]

After farming, the textile is the 2nd largest industry, in terms of number of workers are employed in the industry. In textile industry is classified into 3 sectors: spinning, weaving and finishing. In textile industry there is lot of safety and health problems involved. [2]

Because of the diversity of substrates, methods, gear, and materials employed, as well as the finishing procedures conducted, the textile production business is among the most valuable and technically advanced of all industries.[3]

Textile workers are subjected to a variety of dangers, including physical, chemical, and biological hazards, as well as psychosocial risks such as mental depression and mental instability. [4]

According to a research, the most common work - related risks in the textile sector is lungs illness, which is influenced by reproductive organs disorders, noise-induced loss of hearing, heart-related and vision-related diseases, neurotoxicity and other dermal issues, and mental stress.. [5]

Workers in the textile manufacturing are exposed to a variety of dangers, like noise, chemicals such as dyes, solvents, optical brighteners, finishing additives, and multiple forms of organic and artificial fiber dusts that are harmful to their health, and airborne particles that are harmful to their health.

Regardless of natural or synthetic origin, there is a wide use of chemicals involved already in the production of textile fibers. The textile industry in turn, applies extensive use of chemicals in subsequent processes to manufacture the textile materials, e.g. pretreatment, dyeing, printing, finishing, and coating, as well as washing and drying. [6]

Phthalates are used to increase flexibility and durability of polyvinylchloride (PVC)-based textile coating used to generate patterns and prints on textiles. [7] Several of these chemicals have been related to reproductive toxicity. Textiles are also treated with flame retardants to inhibit ignition. Polybrominateddiphenyl ethers (PBDEs) are used as flame retardants, but19 are persistent environmental pollutants. [8]

Furthermore, surfactants, such as nonylphenolethoxylates, and biocides, for instance triclosan, are widely used in textile materials. The former are toxic to aquatic life, while the latter has been associated to endocrine disruption. [9]

Some toxins, such as methylmercury, will ultimately reach levels in the umbilical cord that are higher than those in the mother's blood. In several situations, concentrations of bisphenol A in fetus plasma are greater than in mother's blood, and the rate of clearing of bisphenol A from the blood is slower in fetuses because of enzymes needed to remove it do not appear till after delivery.[10]

The study's goal was to compare between the effect of maternal exposure to natural fibers and synthetic fibers used in textiles industry among women textile workers, on pregnancy outcome, at Misr Spinning and Weaving Company in El Mahalla El Kubra and Tanta, Egypt.

PATIENTS AND METHODS

The study deals with, comparison between maternal exposure and its consequences to natural fibers and synthetic fibers used in textiles industry on pregnancy outcomes conducted in Corporation with the Egyptian Ministry of Health, at Textile factories in Al-Mahalah Al-Kubra and Tanta, and Faculty of Medicine, Al-Azhar University (Damietta) during the period from February 2021 to February 2022.

A cohort prospective study conducted to investigate the current topic, through the following phases:

Preparatory phase:

During this phase the following steps were done:

Survey of literature: A review of literature was conducted to help in understanding comparison between the effect of maternal exposure to natural fibers and synthetic fibers used in textiles industry on pregnancy outcomes that would help to design and prepare the research questionnaire.

This review of literature was implicated to cover the following subjects: Maternal exposure and its consequences to natural fibers in textiles industry on pregnancy outcomes, Maternal exposure and its consequences to synthetic fibers in textiles industry on pregnancy outcomes and the comparison between both of the above topic.

This survey of literature was based on: The periodical medical journals as British medical journal, some sites from internet such as Goggle, world Health Organization Ministry of Health and Population in Egypt, some text books and some previous researches (national and international).

This study was a cohort prospective study among fifty pregnant women will be included and classified into two groups: **Group I (Exposed group):** Include 25 pregnant women working at Misr Spinning and Weaving Company in Al-Mahalla Al-Kubra and Tanta**. Group II (Non-exposed, Control group):** Included 25 pregnant women work in non- textile polluted area.

This study was conducted on pregnant females with the following characteristics: **Inclusion criteria:** Women textile workers, in Al-Mahalla Al-Kubra, Egypt have a history of at Least 2 years of indoor-exposure to occupational pollution during pregnancy, She works eight hours each day, 5 days each week (fourty hours per week),singleton intrauterine gestation, at 20-40 years old. But **exclusion criteria:**

Presence of consanguinity, multiple pregnancies, women with history of chronic medical disorder, obstetric history show past or recent history of a pregnancy complication, pervious history of infant with congenital malformation to exclude other factors that may affect pregnancy outcome and history of drug medication intake during present pregnancy.

A non-probability (convenient) sample technique will be done to investigate the study. All study subjects matching the inclusion criteria was recruited to participate in this study after take the informed consent until the total target sample size is reached.

The following was done to each participant: history taking, general and local examination and ultrasound will be carried out at first, second and third trimesters.

First-trimester ultrasound scan: It was performed at (11–14eeks): Fetal viability was assessed; fetal crown rump length was measured and anatomical survey.

Second and third trimester ultrasound scans: Fetal anomaly scans at 18- 22 week, uterine artery Doppler was performed at 20-24 weeks of gestation, Doppler on umbilical artery to all suspected cases, screening for gestational diabetes and maternal body mass index (BMI) performed between 24 –30 weeks of gestation

We were study the potential effect of maternal indoor exposure to textile industry in pregnancy and the frequency outcome variables among our two groups which were include the following: abortion, low birth weight (>2500 g), foetal macrosomia (>4000 g), tiny

for stage of pregnancy (less than the sex-specific 10%ile), premature birth (>37 weeks' gestation), extremely premature delivery (>32 weeks'gestation), cesarean section, neonatal mortality (within the first year), Our two groups were analysed in terms of obstetric difficulties, neonatal sickness, and perinatal mortality. Any obstetrics problems were characterised as having several of the following conditions: Pre-eclampsia, prenatal diabetes mellitus, pregnancy-induced high blood pressure, pre-labor rupture of membranes of >24 hours, threatening preterm labour, and postpartum haemorrhage and third-degree tear.

Implementation phase: During this phase the following step were done*:* **Data collection:** The data were collected through (50) visits. The researcher carries out three visits / week. The methods used for data collection through the clinical and laboratory investigations lasted about (10) minute for each one. After taking a formal consent from each participant, assuring confidentiality of the study results, all participants were interviewed to fulfill clinical examination.

Evaluation Phase (Data management phase): During this phase the following activities were done.

Ethical consideration: Consent: Informed consent was taken from all patients and includes: The aim of research and what steps was done. All data was confidential. All data was used in research only and an identified person to whom the relatives were return to at any time for explanations.

Data entry and analysis: Statistical analysis of data was performed including coding, data entering and sorting by Microsoft office 2010 and statistical analysis program IBM Statistical package for social studies (SPSS) version 16.

RESULTS

Items	Case group (n=25)	Control group (n=25)	P value
Age per years			
Mean± SD	30.2 ± 2.3	29.6 ± 3.1	
20 – 30	9 (36%)	10 (40%)	
30 – 40	16 (64%)	15 (60%)	**0.15**
Exposure time(per years)			
Mean ± SD	8.3 ± 0.6		
2- 6	5 (20%)		
6 – 10	11 (44%)		
> 10	9 (36%)		
Pregnancy BMI			
Mean ± SD	29.9 ± 1.9	29.2 ± 2.2	
Underweight	2 (8%)	4 (16%)	**0.87**
Normal	10 (40%)	12 (48%)	
Overweight or obese	13 (52%)	9 (36%)	

S*: P <0.05 (significant)
CD: standard deviation, BMI; body mass index

Table 1: Socio- demographic data of the studied groups

Table (1) showed that there is non-significant differences in mean intra-pregnancy BMI, and age between exposed and control groups. Mean duration of exposure to textile pollution in the exposed group was (8.3±0.6) years; (20 %) exposed between 2 and 6 years; (44 %) exposed between 6 and 10 years and (36%) exposed more than 10 years.

Items	Case group (n=25)	Control group (n=25)	P value
Parity			
- Primigravida	12 (48%)	13(52%)	
- Multigravida	13 (52%)	12(48%)	**0.43**
Mode of delivery			
- Vaginal	11(44%)	10 (40%)	**0.21**
- CS	14 (56%)	15 (60%)	
Maternal hospital stay (hours)			
Mean ± SD			
	34.8 ± 9.1	27.9 ± 6.3	0.01*

*: P <0.05 (significant)
CD: standard deviation, CS; cesarean section

Table 2: Obstetric data of the studied groups

Table (2) showed that longer maternal hospital stay was significantly associated with case group (34.8±9.1 hour) when compared to control group (27.9±6.3 hour). Otherwise, no significant differences were found regarding gravidity, and delivery mode between studied groups.

Items	Case(n=25)		Control (n=25)	P value
	Natural fibers (n=12)	**Synthetic fibers (n=13)**		
Normal outcome	7 (60%)	3 (23%)	21(84%)	**0.02***
PIH	1 (8%)	3 (23%)	1 (4%)	
Miscarriage	0 (0%)	1 (8%)	0 (0%)	
TLBW				**0.01***
• SGA	1 (8%)	2 (17%)	1 (4%)	
• IUGR	1 (8%)	1 (8%)	0 (0%)	
Preterm birth	2 (16%)	4 (35%)	2 (8%)	
Congenital anomalies	0 (0%)	1 (8%)	0 (0%)	

*: P <0.05 (significant)

PIH, Pregnancy induced hypertension; TLBW, Term Low birth weight; SGA; Small for gestational age; IUGR; intrauterine growth retardation

Table 3: Maternal and neonatal outcomes of the studied groups

Table (3) showed that PIH was recorded as outcome in (8%) of pregnancies exposed to Natural fibers versus (23%) pregnancies exposed to Synthetic fibers in contrast to (4%) in the control group. Only 8% of pregnancies exposed to synthetic fibers ended in miscarriage, compared to no statistically important increases in risks for women exposed to natural fibres and none among the control group. (16%) of pregnancies exposed to Natural fibers in the case group were terminated preterm versus (35%) pregnancies exposed to Synthetic fibers in the case group in contrast to (8%) of controls. (16%) of pregnancies exposed to Natural fibers yielded LBW babies at their term, versus (25%) pregnancies exposed to Synthetic fibers compared to (4%) of the control group. It was also noticed that there was marked improvement in neonatal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

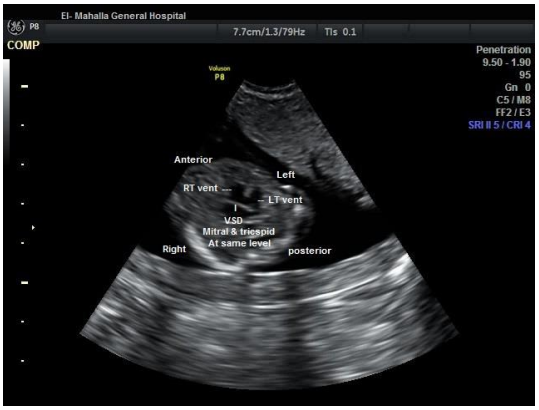

Fig. 1: Trans vaginal Ultrasound of atrio ventricular septal defect at gestational age 17 week

Maternal variables	OR	P value	95% CI
- Maternal age	0.832	0.001*	**0.902 - 0.427**
- Gestational age	0.315	0.001*	**1.002 - 1.132**
- BMI	0.975	0.089	**1.106 - 1.721**
- Mode of delivery	0.815	0.192	**0.967 - 0.812**
- Gravidity	0.525	0.073	**0.282 - 0.954**
- Textile exposure	1.469	0.002*	**0.654 - 0.311**
- Exposure time	0.847	0.003*	**1.263 - 0.822**

*: P <0.05 (significant)

OR, odds ratio; CI, confidence interval; BMI; body mass index

Table 4: Univar-able regression analysis for prediction of abnormal pregnancy outcome

Table (4) showed that the most potent variables that were linked to a significantly higher chances of having an abnormal pregnancy outcome in uni variable analysis, were younger maternal age; OR 0.832 (95% CI, 0.812-0.902), gestational age OR 0.315 (95% CI, 0.228-0.427), textile exposure OR 1.469 (95% CI, 1.263-1.721) and more evidently longer duration of textile exposure OR 0.847 (95% CI, 0.822-0.967).

DISCUSSION

The findings of our research demonstrated a strong link between exposures to the textile induced pollution among the textile pregnant women and our adverse pregnancy outcomes: miscarriage, PIH, preterm birth, TLBW, and congenital anomalies. There was a statistically significant variance among natural and synthetic fiber exposure.

In this study we found only (8%) of pregnancies exposed to Synthetic fibers were Miscarriages while There were no significant positive increases in risks for females who were exposed to natural fibers and none was reported among control group. There was significant statistical difference between natural and synthetic fibers. It was also noticed that there was marked improvement in maternal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

In a study from FinlandTextile spinning (OR=1.3, 95 percent confidence interval [CI]: 1.0–1.9), as well as weaving (OR=1.4, 95 percent CI: 1.1–1.9), fabric inspection (OR=1.5, 95 percent CI: 1.0–2.4), and other textile activity (OR=1.4, 95 percent CI: 1.0–2.0), has been linked to a higher risk of abortion. In a separate Finnish study, Women who worked in a textile factory had a higher rate of abortion (16.7% vs. 11.4%), while a study of maternal occupation in the textile sector in the United States revealed no significant increase in the risk. [11]

Factory employees (toluene), semiconductor industry workers (glycol ethers), and laboratory employees have all been proven to have an increased risk of abortion when exposed to solvents (toluene and xylene).[12]

Exposure to synthetic fibers (1.89, 95 percent CI: 1.20–3.00) and mixed synthetic and natural fibers (3.31, 95 percent CI: 1.30–8.42) was linked to an increased risk of a spontaneously aborted first pregnancy. There were no significant relationships with quantitative cotton dust or toxin levels of exposure in women worked with solvents, nor were there any significant connections with quantitative cotton dust or endotoxin exposures. When all pregnancies in a woman's reproductive history were evaluated, the associations were strong and similar. Miscarriages may be caused by occupational exposure to synthetic fibers, and this potential should be investigated further.. [13]

In this study pregnancy induced hypertensive (PIH) was recorded as outcome in (16%) of pregnancies exposed to Natural fibers versus (23%) pregnancies exposed to Synthetic fibers in contrast to (4%) in the control group. There was statistically substantial variation among natural and synthetic fibers. It was also noticed that there was marked improvement in maternal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

The prevalence of hypertension among Kannur cotton textile workers was comparable to that of India's general population, which is 21%.[14] According to the phase 1 Integrated Disease Surveillance Project (IDSP) survey report the prevalence of hypertension in Kerala population is 18% [(70)]. The present study finding are similar to a study conducted by Tiwai RR et al. among cotton textile workers of Wardha who found the prevalence to be 20.2%. [15]

In our study the textile workers in the case group were significantly associated neonatal complications when compared to their controls. (16%) of pregnancies exposed to Natural fibers in the case group were terminated preterm versus (35%) pregnancies exposed to Synthetic fibers in the case group in contrast to (8%) of controls. It was also noticed that there was marked improvement in neonatal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

Preterm birth (PTB), known as delivery before the 37th week of pregnancy, has long-term negative effects on neonate growth and can result in stunting. According to a 2014 World Health Organization (WHO) report, PTB is the greatest cause of neonatal mortality and the second largest cause of mortality in infants of five (behind pneumonia).[16]

Unfortunately, many local clinical and community efforts to reduce PTB have ended in failure, and PTB rates are rising in developing and even developed economies, with the underlying causes still unknown.. [17]

Multiple variables, including socioeconomic position, race, genetic influences, medical issues, psychological problems, environmental toxins, and others, have been linked to PTB. Textile air pollution, a significant component of environmental pollution, is recognized as a risk factor for a variety of ailments. [18]

The majority of previous published literatures looked into the links among textile air pollution and PTB; some studies found that the first trimester had the greatest impact, while others found that exposure during the second trimester was linked to higher risk of PTB, and still others found that the third trimester was the most important exposure window for PTB. As a result, determining which pregnancy phase is vulnerable to air pollution exposure for PTB is difficult. Given that air pollutants can have a cumulative effect on fetal growing and development, it may be useful to investigate the effects of air pollutants on PTB over the course of the pregnancy. [19]

The study on the link between air pollution exposure and PTB may give some guidance for reducing air pollution and the prevalence of PTB. The epidemiological data support that air pollution adds to women's risk of PTB, given the number of research that have established a substantial link between maternal air pollution exposures during pregnancy and the risk of PTB. Because of the varying air pollutants and gestational ages, the effect of air pollution on PTB differed. Future research is needed to define an adequate time frame for evaluation and to accurately evaluate air pollution exposure.[19]

Our study show that (16%) of pregnancies exposed to Natural fibers yielded LBW babies at their term, versus (25%) pregnancies exposed to Synthetic fibers compared to (4%) of the control group. It was also noticed that there was marked improvement in neonatal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

The WHO defines low birth weight (LBW) as a birth weight of a live born newborn of 2499 g or less, which is one of the most common undesirable pregnancy outcomes. [20]

According to a 2015 WHO report, approximately 20 million newborn babies born each year with a body weight of less than 2500 grammes, representing for 15.5 percent of all newborns worldwide, with the rate of LBW infants in developing countries (16.5 percent) being more than twice as high as in developed societies (7 percent).[21]

During 1988–1991 in Beijing, a comparable cohort study with 74,671 first-parity live births with

pregnancy ages of 37–44 weeks was done to investigate the links between SO2 and total suspended particles (TSP) and low birth weight. The risk of LBW elevated by 11% (95 percent CI, 1.06–1.16) per 100-ug/m3 rise in S02 and 10% (95 percent CI, 1.05–1.14) per 100-ug/m3 increase in TSP, according to Wang's findings, and the estimated reduction in birth weight was 7.3 g and 6.9 g per 100-ug/m3 increase in SO2 and TSP, respectively.[22]

In this study we found only (8%) of case group' exposed to Synthetic fibers were complicated by congenital anomalies (atrio-ventricular septal defect) while none was reported among pregnancies exposed to Natural fibers and control group. There was significant statistical variance among natural and synthetic fibers. It was also noticed that there was marked improvement in neonatal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

Congenital abnormalities are a major cause of stillbirth, neonatal death, and infant mortality. Congenital abnormalities cause 3.2 million impairments worldwide each year, as well as an estimated 10% of fatalities in children under the age of five.[23]

About 3% of all newborns in the United States are affected by a birth defect.[24]

Congenital malformations account for 5.6 percent of all birth defects in China, with around 900,000 new cases each year. [25]

Most congenital abnormalities are thought to have a complex pathogenesis, with environmental exposures like air pollution considered to play a role. [26]

Environmental exposures' possible influence on congenital abnormalities was recently studied.[27]

Castilla et al., [28] declared that the textile industry was ranked as industry uses diverse potentially teratogenic pollutants with increased risk of congenital anomalies; especially anomalies related the central nervous system on top of which anencephaly and microcephaly.

Bianchi et al., [29] reported hydrocephaly, cleft palate and lip, absent diaphragm, esophageal atresia, absent auditory canal, spina bifida, low set ears, and ventricular septal defect, among the multiple congenital anomalies that have been previously recorded in textile dye-workers.

Dye exposure during pregnancy has been linked to a higher incidence of congenital septal abnormalities. Khattak et al., [30] declared in his study that Pregnant women exposed to organic solvents at work, particularly in the textile industry, had a 13-fold greater risk of significant abnormalities as well elevated risk of abortion in prior pregnancies while working with organic solvents.

CONCLUSION

Pregnant women exposed to textile induced pollutions inside Misr Spinning and Weaving Company at Al Mahalla Al Kubra, at increased risk of the adverse pregnancy outcomes with a particular TLBW, preterm birth, miscarriage hypertension, and congenital anomalies. There was significant statistical difference between natural and synthetic fibers. It was also noticed that there was marked improvement in maternal outcome in group exposed to natural fibers in comparison to synthetic fibers group.

Conflict of interest : none

REFERENCES

1. Tekleselassie TG, Berhe K, Getahun TD, Abebe G and Ageba G. Productivity Determinants in the Manufacturing Sector in Ethiopia: Evidence from the Textile and Garment Industries. *Ethiopian Development Research Institute (EDRI)*. 2018.

2. Kibria G. Identifying and eliminatingindustrial hazards in RMG industries. *International Journal of Scientific Research Engineering and Technology*. 2014; 3:159-66.

3. Hasanbeigi A and Price L. A review of energy use and energy efficiency technologies for the textile industry. *Renewable and Sustainable Energy Reviews*. 2012; 16 (6): 3648-65.

4. Singh N. Safety and health issues in workers in clothing and textile industries. *International Journal of Home Science.* 2016; 2(3):38-40.

5. Sudha B and Meenaxi T. Occupational health hazards in textiles industry. *Asian Journal of Home Science*. 2014; 9(1): 267-71.

6. Le Marechal AM, Križanec B, Vajnhandl S and Valh JV. February).Textile finishing industry as an important source of organic pollutants. In Organic pollutants ten years after the Stockholm convention-*environmental and analytical update*. 2012; 29-54.

7. Li X, Yang Y, Cui X, Li S, Zhu X and Tang S. Determination of Phthalate Esters in Textiles by Solid Phase Extraction and Gas Chromatography–Mass Spectrometry, *Analytical Letters*. 2015; 48: 2544–52.

8. Shaw S. Halogenated Flame Retardants: Do the Fire Safety Benefits Justify the Risks?, *Reviews on Environmental Health*. 2011; 25:261–306.

9. Dann AB and Hontela A. Triclosan: environmental exposure, toxicity and mechanisms of action. *Journal of Applied Toxicology*. 2011; 31(4):285-311.

10. Dorey CN. Chemical Legacy – Contamination of the Child, *Greenpeace UK*, October 2003: pp. 54

11. Teoh PJ, Ridout A, Seed P, Tribe RM, Shennan AH. Gender and preterm birth: Is male fetal gender a clinically important risk factor for preterm birth in high-risk women? *Eur J Obstet Gynecol Reprod Biol.* 2018; 225:155-9.

12. Swan SH, Beaumont JJ, Hammond SK, VonBehren J, Green RS, Hallock MF, et al. Historical cohort study of spontaneous abortion among fabrication workers in the Semiconductor Health Study: agent-level analysis. *Am J Ind Med*. 1995; 28(6):751–69.

13. Wong EY, Ray RM, Gao DL, Wernli KJ, Li W, Fitzgibbons ED, et al. Dust and chemical exposures, and miscarriage risk among women textile workers in Shanghai, China. *Occup Environ Med*. 2009; 66(3):161-8.

14. World Health Organization. A global brief on hypertension. WHO/DCO/ WHD/2013.2. Geneva: *WHO*. 2013; Available from http://www.who.int/ cardiovascular_ diseases/ publications/ global_brief_hypertension/en/.

15. Tiwai RR, Pathak MC, Zodpey SP, Babar VY. Hypertension among cotton textile workers. *Indian J Public Health*. 2003; 47(1):34-6.

16. Fleischer NL, Merialdi M, van Donkelaar A, Vadillo-Ortega F, Martin RV, Betran AP, et al. Outdoor air pollution, preterm birth, and low birth weight: analysis of the world health organization global survey on maternal and perinatal health. *Environ Health Perspect.* 2014; 122(4):425-30.

17. Bekkar B, Pacheco S, Basu R, DeNicola N. Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. *JAMA Netw Open*. 2020; 3(6):e208243.

18. Padula AM, Yang W, Lurmann FW, Balmes J, Hammond SK, Shaw GM. Prenatal exposure to air pollution, maternal diabetes and preterm birth. *Environ Res*. 2019; 170:160-7.

19. Tan Y, Yang R, Zhao J, Cao Z, Chen Y, Zhang B. The Associations Between Air Pollution and Adverse Pregnancy Outcomes in China. In: Ambient Air Pollution and Health Impact in China. Dong GH (ed.), *Springer Nature Singapore Pte Ltd*. 2017; pp. 181-214.

20. Jacobs M, Zhang G, Chen S, Mullins B, Bell M, Jin L, et al. The association between ambient air pollution and selected adverse pregnancy outcomes in china: a systematic review. *Sci Total Environ*. 2016; 579:1179.

21. Lamichhane DK, Leem JH, Lee JY, Kim HC. A meta-analysis of exposure to particulate matter and adverse birth outcomes. *Environ Health Toxicol*. 2015; 3(30):e2015011.

22. Wang X, Ding H, Ryan L, Xu X. Association between air pollution and low birth weight: a community-based study. *Environ Health Perspect*. 1997; 105(5):514–20.

23. Chen EK, Zmirounavier D, Padilla C, Deguen S. Effects of air pollution on the risk of con-genital anomalies: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2014; 11:7642–68.

24. Home C. Update on overall prevalence of major birth defects – Atlanta, Georgia, 1978–2005. *Morb Mortal Wkly Rep*. 2008; 57:1–5.

25. Yu M, Ping Z, Zhang S, He Y, Dong R, Guo X. The survey of birth defects rate based on birth registration system. *Chin Med J (Engl).* 2015; 128(1):7–14.

26. Ritz B. Air pollution and congenital anomalies. *Occup Environ Med*. 2010; 67:221–2.

27. Vrijheid M, Martinez D, Manzanares S, Dadvand P, Schembari A, Rankin J, et al. Ambient air pollution and risk of congenital anomalies: a systematic review and meta-analysis. *Environ Health Perspect*. 2011; 119:598–606.

28. Castilla EE, López-Camelo JS, Campaña H, Rittler M. Epidemiological methods to assess the correlation between industrial contaminants and rates of congenital anomalies. *Mutat Res*. 2001; 489(2-3):123-45.

29. Bianchi F, Cianciulli D, Pierini A, Seniori Costantini A. Congenital malformations and maternal occupation: a registry-based case-control study. *Occup Environ Med*. 1997; 54: 223-8.

30. Khattak S, K-Moghtader G, McMartin K, Barrera M, Kennedy D, Koren G. Pregnancy Outcome Following Gestational Exposure to Organic Solvents. A Prospective Controlled Study. *JAMA*. 1999; 28: 1106 - 9.