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Correlation between preconception maternal non-occupational exposure to interior decoration or oil paint odour and average birth weight of neonates: findings from a nationwide cohort study in China's rural areas

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ABSTRACT

Background Birth weight is a critical indicator of neonatal health and foretells people's health in adolescence and even adulthood. Some researchers have warned against the adverse effects on babies' birth weight of exposure to pollutants in interior decoration or oil paint by odour intake. This study evaluated the effects of maternal exposure to such factors before conception on the birth weights of neonates.

Methods Data on 213 461 cases in this study were from the database of the free National Pre-pregnancy Checkups Project. Defined as 'exposed' were those women exposed to oil paint odour or interior decoration at home or in the workplace within 6 months before their pregnancy. The study focused on revealing the correlation between such exposure and the birth weight of the neonates of these women, especially the incidence of macrosomia and low birth weight (LBW). Statistical analysis was conducted using the Kruskal–Wallis H test, the Mann–Whitney U test and logistic regression.

Results The birth weight of babies from mothers non-occupationally exposed to such settings averaged 3465 g (range 3150–3650 g), whereas the birth weight of those from mothers free of such exposure averaged 3300 g (range 3000–3600g). Maternal exposure preconception to interior decoration or oil paint odour reduced the incidence of LBW in their babies (p=0.003, OR 0.749, 95% CI 0.617 to 0.909). Such exposure may also augment the probability of macrosomia (p<0.001, OR 1.297, 95% CI 1.133 to 1.484).

Conclusion Maternal exposure to interior decoration or oil paint odour preconception may increase the average birth weight of neonates, as well as the incidence of macrosomia.

Strengths and limitations

- Limitations: all cases in the study came from rural areas in China, and the specific ingredients of interior decoration or oil paint odour in question were not illustrated in detail.
- Strengths: a large number of participants were included, from a wide demographic area, making this the first high quality study on this subject in China or possibly the world. The National Pre-pregnancy Checkups Project, which is currently under way, may provide more evidence and further support of the results of this study in the future.

INTRODUCTION

Birth weight is not only an important indicator of neonatal health in the perinatal period, but is also associated with health during adolescence and even into adulthood.[1] It has been widely accepted that infants with a birth weight lower than normal are faced with a higher incidence of conditions such as neonatal respiratory distress syndrome, retinopathy of prematurity and necrotising enterocolitis.[2] Analogously, the delivery of large fetuses is a major concern to obstetricians. Recent clinical researchers found that babies with macrosomia were more likely to be admitted to the neonatal intensive care unit for the 3.2-fold higher risk of hypoglycaemia and the 1.2-fold higher risk of asphyxia in the neonatal period. Moreover, babies with macrosomia also suffered from a higher prevalence of congenital anomaly and aspiration pneumonia. These add to the financial burdens of hospitals, family and society in general.[2] In addition, these babies are more vulnerable to impaired glucose tolerance, obesity or an abnormal lipid profile, which can ultimately lead to metabolic syndrome in the long term.[3] These are

the reasons for clinicians making painstaking efforts to elucidate the causes of gestation overgrowth and whether the growth trajectory can be altered.[4]

It is clear that both genetic and environmental factors are among the determinants of birth weight.[5] There are reports inferring macrosomia as genetically preprogrammed, and no antepartum interventions can alter the pregnancy outcome. However, others claimed 15 years ago that 40% of birth weight was determined by heredity.[6] No update of these data has been reported although some researchers claim that birth weight is primarily determined by maternal height, and genetic variations account for only 20% of final height.[7] We believe that environmental factors are major determinants of birth weigh, and have pinpointed the influence of environmental factors, namely pollutants in interior decoration or oil paint odour.

Organic solvents, commonly found in daily life, are important constituents in the effects of environmental factors on birth weight. For their extensive use in oil paints and cleaning agents, the National Institute for Occupational Safety and Health, USA, named 10 organic solvents as the top chemicals in occupational exposure—benzene, xylene, toluene, carbon tetrachloride, chloroform, methylene chloride, perchloroethylene, trichloroethylene, 1,1,1-trichloroethane and the petroleum based mixture Stoddard solvent.[8] Associations have been found that occupational exposure of pregnant women to certain types of organic solvents contributes to a higher risk of adverse pregnancy outcomes, including preterm birth, spontaneous abortion, congenital malformations and signs of underdevelopment during gestation, compared with infants delivered by unexposed women.[9] Conversely, little attention has been directed to exposure to non-occupational organic solvents, especially interior decoration or oil paint odour, in spite of their widespread use in daily life. A literature review found only one investigation conducted in Denmark[10] regarding the influence of non-occupational solvent exposure on pregnancy outcomes. However, it failed to identify and clarify the effects of non-occupational exposure to paint odour on women during their pregnancy. In light of this, our research focused on revealing the association between maternal pre-pregnancy non-occupational exposure to interior decoration or oil paint odour, and the birth weights of their babies.

In view of the limitations of previous studies on non-occupational organic solvent exposure and pregnancy outcomes, this study was a population based investigation on the association between maternal exposure to decoration odour at home before pregnancy and birth weight of the babies. This national prospective research is designed to determine the influence of maternal non-occupational exposure to decoration odour on the birth weight of neonates.

METHODS

Study population

The data used in this study were from the database of the free National Pre-pregnancy Checkups Project (NPCP), which is a population based cohort study across the country. In order to minimise congenital defects and promote the constitutional health of the Chinese population, the NPCP was initiated by the Chinese National Health and Family Planning Commission and Ministry of Finance in 2010. Qualified and recruited couples are those living in the designated rural areas that are expected to be pregnant within the next 6 months, and they are provided with a free preconception physical examination. The programme established medical records for all the recruited couples, comprising information such as past medical history, family history and data from a series of free medical examinations, including physical examinations, laboratory tests and imaging results. They were also provided with professional preconception counselling based on the medical information and their test results. All files were archived in a web based online collection system of the national data centre. The programme was in compliance with the Code of Ethics of the World Medical Association, and was approved by the National Health and Family Planning Commission of the People's Republic of China (NHFPC). Further information on this programme was reported by Wang *et al*.[11] We obtained authorisation to analyse these data from the Department of Maternal and Child Healthcare of the NHFPC.

In the first stage of the programme in 2010, participants were enrolled mostly from 100 pilot rural areas, designated because of access to medical professionals and well trained health workers, as well as the availability of sophisticated equipment for examinations. With detailed operational guidelines finalised in practice, the number of pilot areas was increased to 220 in 2012, and further extended to most areas across the country.[12] By the end of 2013, the programme covered 11.42 million families, with 248 501 births in total. This study focused on the 213 461 singleton babies who were born alive with gestational ages of 24–42 weeks. The participant recruitment process is shown in figure 1.

Study procedure

Each couple was interviewed on three occasions: the first immediately after admission to the programme before conception, in their demographic property; the second 3 months after pregnancy by phone call; and the last within 1 month of delivery.

During the preconception interview, clinical data for the physical and biochemical examinations were obtained by experienced medical staff, including measurements of maternal and paternal height, weight, blood pressure and haemoglobin levels. At the same time, basic information such as maternal and paternal demographic property, nationality, home address, socioeconomic background, reproductive history and medical history were collected using standard questionnaires. At the same time, the exposure status of the women to decoration odours before pregnancy was recorded based on their answer to a 'yes or no' question, namely "Were you exposed to any interior decoration or oil paint odour

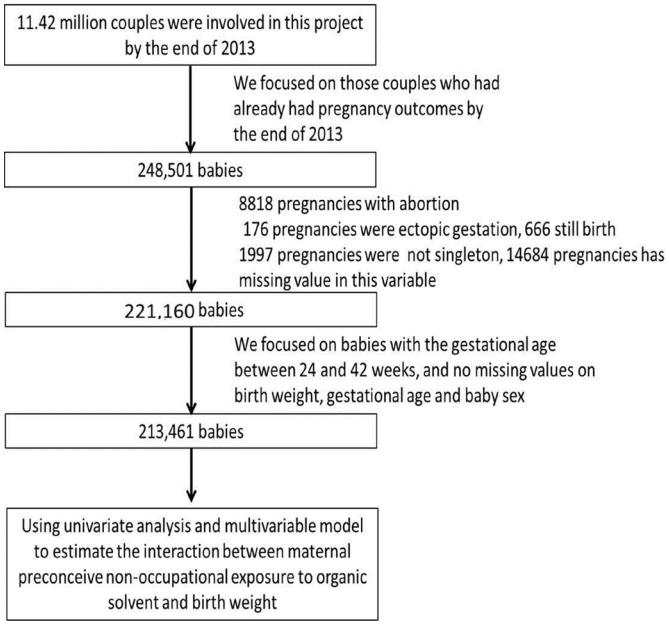

Figure 1 Flowchart of participant recruitment.

at your residence or workplace within 6 months before you got pregnant?" The interview during pregnancy was designed to obtain medical information since their last menstrual period. The information recorded in the first month after delivery at the last follow-up by means of a face to face talk or telephone interview was gender and birth weight of the newborn, as well as the age of the mother at delivery. All data were entered into a central database.

Definition of variables

Gestational age was calculated from the first day of the last menstrual period to birth, and preterm birth was defined as birth before the 37th week of gestation. Babies born between 37 and 42 weeks were categorised as full term infants, and those born after 42 weeks as post-mature. Our study defined babies with a birth weight <2500 g as low birth weight (LBW),[13] and macrosomia as those with a birth weight exceeding 4000 g[14]. The rest of the babies were classified as normal.

In the data analysis, those subjects whose nationality was other than Han fell into one minority group category. Occupationally, subjects fell into five categories—'physical labour', 'service provision', 'mental labour', 'unemployed' and 'others'. China's characteristic demographic property (hukou) categorises its nationals into rural and urban. Those who live in rural areas and mainly depend on agriculture for a living fall into the rural hukou (demographic property) category, while others are in the urban hukou category. The study also covered maternal diet during pregnancy based on two covariates, or two yes or no questions, "Do you take meat and eggs in your daily diet during pregnancy" and "Do you take enough vegetables/fruits in your daily diet during pregnancy".

Statistical analysis

As not all measurements have normal distribution, the data were expressed as mid-values (25th percentile and 75th percentile) to describe the demographic characteristics of all of the participants. The Kruskal–Wallis H test and the Mann–Whitney U test were used to determine whether the differences between measurements in the different groups were of statistical significance. The enumeration data were subject to the χ^2 test to identify statistical differences among groups. The constituent proportions are listed in parentheses. The χ^2 test was also used to identify the association between exposure to organic solvents and the incidence of LBW and macrosomia. Two sided p values <0.05 were considered statistically significant. Odds ratios (OR) for LBW and macrosomia were also calculated, and two sided 95% confidence intervals (CI) were obtained in the χ^2 test.

As found in existing studies in this area, babies' gender,[15] maternal baseline body mass index (BMI), parity, nationality,[16] occupations and demographic property[17] are factors that influence the birth weight of babies. Moreover, maternal diet, such as intake of meat and eggs and vegetable deficiency may also affect birth weight. Therefore, in order to adjust the effects of these potential confounders on the correlation between non-occupational interior decoration or oil paint odour exposure and birth weight of the neonates, we created adjusted models by using these eight covariates and maternal non-occupational exposure to interior decoration or oil paint odour by logistic regression. All statistical analyses were conducted with SPSS V.20.0.

RESULTS

Characteristics of the study population

As shown in figure 2, a total of 12 373 of the 213 461 babies were diagnosed as LBW, accounting for 5.8% of all births, whereas 16 373 who weighed >4000 g were diagnosed as macrosomia, accounting for 7.7%. The baseline characteristics for the continuous variables of the participants

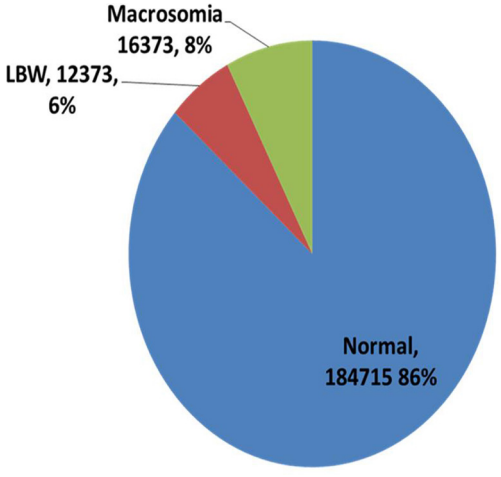

Figure 2 Proportions of macrosomia and low birth weight (LBW).

Table 1 Baseline characteristics for the continuous variables of the participants

Group	Exposure to interior decoration or oil paint odour		p Value
	Yes	No	
Maternal age at delivery (years)	24 (22, 27)	24 (22, 27)	0.298
Maternal body mass index (kg/cm^2)	20.70 (19.43, 22.27)	20.57 (19.25, 22.22)	<0.001
Birth weight of neonates (g)	3465 (3150, 3650)	3300 (3000, 3600)	<0.001

are displayed in table 1, and those for the categorical variables are listed in table 2. As indicated, all factors, except for the childbearing age of the mother, were distributed differently between the different groups.

Exposure to interior decoration or oil paint odour and birth weight

This study found that only 2444 (1.1%) of the women surveyed were exposed to interior decoration or oil paint odour in their residence or workplace before pregnancy. The average birth weight of the babies whose mothers had non-occupational exposure to decoration pollutants was 3465 g (range 3150–3650 g), whereas the mean birth weight of those from mothers free of such exposure was 3300 g (range 3000–3600 g). We used the Mann–Whitney U and the χ^2 tests to compare the average birth weights between the two groups, and the difference was of statistical significance (p<0.001).

As shown in table 3, other than greater average birth weight, non-occupational exposure to interior decoration or oil paint odour before pregnancy reduced the incidence of giving birth to a LBW baby (p=0.003, OR=0.749, 95% CI 0.617 to 0.909). Such exposure may also have increased the probability of giving birth to babies with macrosomia (p<0.001, OR=1.297, 95% CI 1.133 to 1.484). In addition, these effects were still significant after adjustment for factors such as babies' gender, maternal BMI, demographic property, nationality, occupation, being a primipara, intake of meat and eggs in the daily diet during pregnancy and intake of enough vegetables/fruits in the daily diet during pregnancy (tables 4 and 5).

DISCUSSION

The only previous report found in literature on this subject was the study from Denmark which discussed the cross talk between non-occupational exposure to oil paint odour and its effects on fetal growth of their babies. It found that non-occupational exposure of mothers to oil paint odour might decrease the risk of giving birth to small for gestational age (SGA) babies, but the researchers failed to find any connection between exposure to non-occupational oil paint odour and birth weight.[10] Our study however found that such an exposure may be associated with greater average birth weight of neonates, and a lower incidence of LBW, which seemed to be a favourable factor in pregnancy. However, the results revealed that it is associated with an increased incidence of macrosomia. These findings suggest that non-occupational exposure to interior decoration or oil paint odour of women before pregnancy may influence pregnancy outcomes.

Although the correlation between exposure to interior decoration or oil paint odour and birth weight remains a statistical question and no solid conclusion can be made, we have tried to decipher the mechanism of how maternal non-occupational exposure to interior decoration or oil paint odour influences greater birth weight.

Some researchers believe that maternal exposure to organic solvents affects fetal growth because of the constriction effect on the blood vessels throughout the body, including those responsible for the placental blood supply. These solvents may induce hypoxia, fetal malnutrition and ultimately other adverse pregnancy outcomes.[18] However, anoxia is always held responsible for LBW or SGA,[19] but it does not increase the baby's birth weight or the risk of macrosomia, which points to other mechanisms

Table 2 Baseline characteristics for categorical variables of the participants

		Birth weigh group				
	Subgroup	LBW (%)	Normal (%)	Macrosomia (%)	p Value	Missing value
Neonates' sex	Male (52.8)	6223 (50.3)	96 743 (52.4)	9776 (59.7)	<0.001	0
	Female (47.2)	6150 (49.7)	87 972 (47.6)	6597 (40.3)		
Maternal demographic property	Agricultural (94.0)	11 557 (93.5)	173 390 (93.9)	200 435 (94.7)	<0.001	137
	Non-agricultural (6.0)	808 (6.5)	11 207 (6.1)	12 889 (5.3)		
Maternal nationality	Han (94.8)	11 669 (94.3)	174 957 (94.7)	15 657 (95.6)	<0.001	0
	Minority (5.2)	704 (5.7)	9758 (5.3)	716 (4.4)		
Primipara	Yes (31.8)	3803 (32.0)	56 338 (31.6)	5362 (33.8)	<0.001	7275
	No (68.2)	8065 (68.0)	122 123 (68.4)	10 495 (66.2)		

LBW, low birth weight.

Table 3 Relationships between maternal exposure to interior decoration or oil paint odour and macrosomia or low birth weight (LBW)

		LBW				Macrosomia			
		LBW (yes/no)			OR	Macrosomia (yes/no)			OR
Group		No	Yes(%)	p Value	(95% CI)	No	Yes(%)	p Value	(95% CI)
Exposure to interior decoration or oil paint odour	Yes	2236	108 (4.4)	0.003	0.749 (0.617 to 0.909)	16136	237 (1.45)	<0.001	1.297 (1.133 to 1.484)
	No	198750	12682 (5.8)			194879	2207 (1.12)		

to explain the correlation between maternal exposure to decoration pollutants and fetal growth.

As evidenced in some observational studies, fasting blood glucose,[20] fasting insulin and HOMA-IR[21] levels were found to be significantly higher in those exposed to a mixture of organic solvents than those in the non-exposed control group. Given the absence of published reports for specific pathways linking organic solvents to glucose metabolism impairment, previous investigations have pointed out that organic solvents may negatively influence insulin synthesis and secretion by the action of tumour necrosis factor α (TNFα). Some researchers discovered that serum TNFα levels were significantly elevated in house painters, while activities of antioxidant enzymes such as superoxide dismutase and glutathione peroxidase were significantly downregulated in these workers.[22] Others have claimed that TNFα may antagonise the action of adiponectin through autocrine and paracrine pathways.[23] TNFα may also downregulate the level of insulin stimulated tyrosine phosphorylation of the insulin receptor and insulin receptor substrate-1, resulting in insulin resistance.[24] In addition, TNFα is capable of promoting lipolysis in adipose tissue and results in increased plasma concentrations of free fatty acids. This may lead to excessive hepatic glucose and very low density lipoprotein secretion, while muscular glucose uptake and metabolism will also be inhibited, and all these biological process will ultimately impair insulin sensitivity.[25] It has been widely accepted that there is a clear link between impairment of maternal glucose metabolism and increased birth weight of babies and macrosomia.[26] This may explain the mechanism of maternal non-occupational exposure to interior decoration or oil paint odour and its correlation with increased birth weight. However, further study is necessity to establish and confirm this direct link.

There may be socioeconomic causes for the correlation between maternal non-occupational exposure to interior decoration or oil paint odour and fetal growth. The financial conditions of a family may affect the choice of decoration materials or even the decision to decorate, hence influencing the carbohydrate intake of women during pregnancy, and ultimately babies' birth weights.

STRENGTHENS AND LIMITATIONS

Strengthens

Our investigation is the first and largest Chinese study elucidating the relationship between maternal non-occupational exposure to interior decoration or oil paint odour and birth weight of babies. The large number and wide coverage of participants ensures the high reliability of the results of this study.

The ongoing NPCP will harvest more data as it proceeds, providing further evidence of the findings in this study.

Table 4 Logistic regression model for adjusting the influence of the baseline characteristics and low birth weight

				95% CI of OR	
	β value	p Value	OR	Lower limit	Upper limit
Maternal exposure to interior decoration or oil paint odour	−0.284	0.005	0.753	0.619	0.917
Maternal body mass index	−0.006	0.085	0.994	0.988	1.001
Maternal occupation	0.010	0.398	1.010	0.987	1.033
Primipara or not	0.015	0.475	1.015	0.974	1.058
Maternal nationality	0.077	0.076	1.080	0.992	1.177
Maternal demographic property	0.060	0.180	1.062	0.973	1.159
Intake of meat and eggs in daily diet	−0.222	<0.001	0.801	0.726	0.883
Intake of enough vegetables/fruits in daily diet or not	0.086	0.127	1.089	0.976	1.216
Baby's gender	0.110	<0.001	1.116	1.075	1.159
Constant	−2.700	<0.001	0.067		

Table 5 Logistic regression of the baseline characteristics and macrosomia

	β value	p Value	OR	95% CI of OR	
				Lower limit	Upper limit
Maternal exposure to interior decoration or oil paint odour	0.267	<0.001	1.306	1.140	1.497
Maternal body mass index	0.013	<0.001	1.014	1.010	1.017
Maternal occupation	–0.001	0.886	0.999	0.979	1.019
Primipara or not	0.083	<0.001	1.087	1.049	1.126
Maternal nationality	–0.247	<0.001	0.781	0.718	0.849
Maternal demographic property	–0.115	0.006	0.891	0.821	0.968
Intake of meat and eggs in daily diet	–0.066	0.154	0.936	0.855	1.025
Intake of enough vegetables/fruits in daily diet or not	0.088	0.075	1.092	0.991	1.202
Baby's gender	–0.309	<0.001	0.734	0.710	0.760
Constant	–2.191	<0.001	0.112		

Limitations

The data on maternal exposure to interior decoration or oil paint odour were collected by means of self-report of yes/no questions, a type of field survey, thus incurring possible self-report bias and information bias.

In the design of the NPCP, exposure to interior decoration or oil paint odour cannot be categorised based on duration, patterns, variety of ingredients or exposure dosage.

CONCLUSIONS

This study found an association between maternal non-occupational exposure to organic solvents before pregnancy with higher birth weight of neonates, as well as an increased incidence of macrosomia. Its large participant size and vast geographical coverage ensures the reliability of the results of the study. Definitive conclusions on the correlation between maternal exposure to interior decoration or oil paint odour and birth weight there will require an improved study design.

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Competing interests None declared.

Patient consent Obtained.

Ethics approval The study was approved by the Research Association for Women and Children's Health.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement HL and SC had full access to all of the data in the study, and extra data are available by emailing them.

REFERENCES

1. Bielemann RM, Gigante DP, Horta BL. Birth weight, intrauterine growth restriction and nutritional status in childhood in relation to grip strength in adults: from the 1982 Pelotas (Brazil) birth cohort. *Nutrition* 2016;32:228–35.
2. Xu H, Simonet F, Luo ZC. Optimal birth weight percentile cut-offs in defining small- or large-for-gestational-age. *Acta Paediatr* 2010;99:550–5.
3. Wang D, Hong Y, Zhu L, *et al*. Risk factors and outcomes of macrosomia in China: a multicentric survey based on birth data. *J Matern Fetal Neonatal Med* 2017;30:623–7.
4. Campaigne AL, Conway DL. Detection and prevention of macrosomia. *Obstet Gynecol Clin North Am* 2007;34:309–22.
5. Gielen M, Lindsey PJ, Derom C, *et al*. Modeling genetic and environmental factors to increase heritability and ease the identification of candidate genes for birth weight: a twin study. *Behav Genet* 2008;38:44–54.
6. Sohl B, Moore TR. Alteraciones del crecimiento fetal. In: *Tratado de Neonatologı' a de Avery*. Madrid: Harcourt, 2000–45–55.
7. Lango Allen H, Estrada K, Lettre G, *et al*. Hundreds of variants clustered in genomic loci and biological pathways affect human height. *Nature* 2010;467:832–8.
8. Desrosiers TA, Lawson CC, Meyer RE, *et al*. Assessed occupational exposure to chlorinated, aromatic and Stoddard solvents during pregnancy and risk of fetal growth restriction. *Occup Environ Med* 2015;72:587–93.
9. Garlantézec R, Monfort C, Rouget F, *et al*. Maternal occupational exposure to solvents and congenital malformations: a prospective study in the general population. *Occup Environ Med* 2009;66:456–63.
10. Sørensen M, Andersen AM, Raaschou-Nielsen O. Non-occupational exposure to paint fumes during pregnancy and fetal growth in a general population. *Environ Res* 2010;110:383–7.
11. Zhang S, Wang Q, Shen H. [Design of the national free proception health examination project in China]. *Zhonghua Yi Xue Za Zhi* 2015;95:162–5.

12. Wang QM, Zhang SK, Hu M, *et al*. Establishment of quality assurance system of the National Free Preconception Health Examination Project in China. *Zhonghua Yi Xue Za Zhi* 2015;95:166–8.
13. American College of Obstetricians and Gynecologists. Perinatal care at the threshold of viability. *ACOG Practice Bulletin #38*. Washington DC: American College of Obstetricians and Gynecologists, 2002.
14. Langer O, Berkus MD, Huff RW, *et al*. Shoulder dystocia: should the fetus weighing ≥4000 grams be delivered by cesarean section? *Am J Obstet Gynecol* 1991;165:831–7.
15. Katz J, Wu LA, Mullany LC, *et al*. Prevalence of small-for-gestational-age and its mortality risk varies by choice of birth-weight-for-gestation reference population. *PLoS One* 2014;9:e92074.
16. Ziadeh S. Obstetric outcome of teenage pregnancies in North Jordan. *Arch Gynecol Obstet* 2001;265:26–9.
17. Poeran J, Maas AFG, Birnie E, *et al*. Social deprivation and adverse perinatal outcomes among Western and non-Western pregnant women in a dutch urban population. *Soc Sci Med* 2013;83:42–9.
18. Forand SP, Lewis-Michl EL, Gomez MI. Adverse birth outcomes and maternal exposure to trichloroethylene and tetrachloroethylene through soil vapor intrusion in New York State. *Environ Health Perspect* 2011;120:616–21.
19. Salmaso N, Dominguez M, Kravitz J, *et al*. Contribution of maternal oxygenic state to the effects of chronic postnatal hypoxia on mouse body and brain development. *Neurosci Lett* 2015;604:12–17.
20. Merker GH, Metzner G, Raabe F. TH1-directed modulation of in vitro cytokine production in human peripheral blood mononuclear cells by styrene-7.8-oxide. *Toxicol Lett* 2006;160:105–11.
21. Won YL, Ko Y, Heo K-H, *et al*. The effects of long-term, low-level exposure to monocyclic aromatic hydrocarbons on worker's insulin resistance. *Saf Health Work* 2011;2:365–74.
22. Karagözler AA, Mehmet N, Batçioglu K. Effects of long-term solvent exposure on blood cytokine levels and antioxidant enzyme activities in house painters. *J Toxicol Environ Health A* 2002;65:1237–46.
23. Shapiro L, Scherer PE. The crystal structure of a complement-1q family protein suggests an evolutionary link to tumor necrosis factor. *Current Biology* 1998;8:335–40.
24. Hotamisligil G, Peraldi P, Budavari A, *et al*. IRS-1-Mediated inhibition of insulin receptor tyrosine kinase activity in TNF-alpha- and obesity-induced insulin resistance. *Science* 1996;271:665–70.
25. Ruan H, Lodish HF. Insulin resistance in adipose tissue: direct and indirect effects of tumor necrosis factor-α. *Cytokine Growth Factor Rev* 2003;14:447–55.
26. Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. *Am J Obstet Gynecol* 2004;191:964–8.

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