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Association between prenatal exposure to cooking oil fumes and full-term low birth weight is mediated by placental weight

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ABSTRACT

Objective: Evidence regarding the association between prenatal exposure to cooking oil fumes (COF) and full-term low birth weight (FTLBW) is still controversial, and the mechanism remains unclear. This study thus aims to explore the association of prenatal COF exposure with off-spring FT-LBW as well as the mediating role of placenta in their association.

Methods: A case-control study enrolling 266 pregnant women delivering FTLBW newborns (cases) and 1420 delivering normal birth weight (NBW) newborns (controls) was conducted. Information on prenatal COF exposure, socio-demographics, and obstetric conditions were collected at the Women's and Children's Hospitals of Shenzhen and Foshan in Guangdong, China. Linear and hierarchical logistic regression models were undertaken to explore the associations among COF exposure, placenta and birth weight, as well as the mediation effect of placental weight.

Results: After controlling for potential confounders, prenatal COF exposure was significantly associated with the higher risk of FT-LBW (OR = 1.31, 95% CI = 1.06–1.63) and the lower placental weight (ß = −0.12, 95% CI = −0.23 ~ −0.005). Compared with mothers who never cooked, those cooking sometimes (OR = 2.99, 95% CI = 1.48–6.04) or often (OR = 3.41, 95% CI = 1.40–8.34) showed a higher risk of FT-LBW, and likewise, those cooking for less than half an hour (OR = 2.08, 95% CI = 1.14–3.79) or cooking between half to an hour (OR = 2.48, 95% CI = 1.44–4.29) were also more likely to exhibit FT-LBW. Different cooking methods including pan-frying (OR = 2.24, 95% CI = 1.30–3.85) or deep-frying (OR = 1.78, 95% CI = 1.12–2.85) during pregnancy were associated with increased FT-LBW risks as well. The further mediation analysis illustrated that placental weight mediated 15.96% (95% CI: 12.81~28.80%) and 15.90% (95% CI = 14.62%~16.66%) of the associations of cooking during pregnancy and frequency of prenatal COF exposure, respectively, with FT-LBW.

1. Introduction

Recently, with the rapid economic development in China, lighter pollutant fuels (e.g., natural gas, petroleum gas, and electricity) have been widely used as the primary cooking fuels in urban communities, and thus indoor air pollution (IAP) from solid fuels (such as coal and biomass) has no longer been a prominent public health concern. In contrast, due to the long-standing influence of traditional food culture, Chinese people are accustomed to cooking at home by means of deep-frying, pan-frying and stir-frying, which tends to produce an extensively larger amount of lampblack when compared with the single way of cooking in Western culture (Wang et al., 2017). The Chinese cooking styles often involve volatilization of cooking oil fumes (COFs) which can potentially produce a large number of pollutants and is an important source of IAP, and the cooks may always inhale high concentrations of COFs (Cheng et al., 2016). COFs are the mixture of chemicals including particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), organic carbon (OC), volatile organic compounds (VOCs) and carbonyl compounds (Yao et al., 2015; Ke et al., 2016; Peng et al., 2017; Li et al., 2018). Under certain conditions, the hazardous substances contained in COFs may be absorbed into the human body and consequently result in adverse effect on health. Considering the

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multiple effects of COFs and the China's featured cooking traditions, it is imperative that we explore and deal with the influences of COF exposure. Chinese COFs emissions has thus been a hot research topic over the last two decades, and a series of epidemiological studies have reported that the exposure to COFs is associated with adverse health outcomes including lung cancer (Wang et al., 2017; Xue et al., 2016), oral cancer (He et al., 2016), cervical intraepithelial neoplasm (Wu et al., 2004), chronic bronchitis (Chen et al., 2018a), cervical precancerous lesions (Lee et al., 2010), sleep disorders (Wei et al., 2017), etc.

However, whether COF exposure during pregnancy affects offspring's birth outcomes still remains poorly understood. One recent study by Wang et al. (2018) indicated that prenatal exposure to COFs for 0–1 h per day was significantly associated with large for gestational age (LGA) newborns, while exposure > 1 h per day was associated with small for gestational age (SGA) newborns but with no statistical significance. Other studies investigated exposure to a specific component in COFs (e.g., PAHs, PMs and VOCs) and demonstrated its association with abnormal birth weight (Perera et al., 2003; Forand et al., 2012; Sapkota et al., 2012), while none of these studies looked at COF as a whole. Although the health effect of COF exposure has been poorly studied, previous research, yet, has focused extensively on examining the effects of prenatal exposure to other IAP (especially from using solid fuels) on neonatal birth outcomes for many years. These epidemiological studies, despite of varieties in their study designs, have obtained consistent results as follows. For instance, a meta-analysis on the results of studies across developing countries indicated that IAP from using solid fuels increased the risk of low birth weight (LBW) and stillbirth and reduced the mean birth weight by 95.6 g (95% CI: 68.5, 124.7 g) (Pope et al., 2010). Another recent meta-analysis on 19 studies showed that household combustion of solid fuels resulted in an 86.43 g (95% CI: 55.49, 117.37) reduction in birth weight, and a 35% (EE= 1.35, 95% CI: 1.23, 1.48) and 29% (EE= 1.29, 95% CI: 1.18, 1.41) increase in the risk of LBW and stillbirth, respectively (Amegah et al., 2014). Besides, a number of studies across the world further confirmed that prenatal exposure to IAP from biomass, kerosene or solid fuels could cause LBW (Epstein et al., 2013; Jiang et al., 2015; Khan et al., 2017) or SGA (Yucra et al., 2014), preterm birth (Jiang et al., 2015; Wylie et al., 2014), still birth (Wylie et al., 2014; Lakshmi et al., 2013; Patel et al., 2015), neonatal death (Epstein et al., 2013; Khan et al., 2017; Patel et al., 2015), as well as reduced birth weight (Jiang et al., 2015; Wylie et al., 2014; Milanzi and Namacha, 2017). These above studies consistently indicated that IAP exposure during in utero life was related to adverse birth outcomes. We are therefore interested in understanding whether prenatal exposure to COF, as an important component of IAP and probably the most major source of IAP in China considering the traditional Chinese food culture and local cooking habits (Liu et al., 2015), may also affect fetal outcomes such as birth weight.

Furthermore, it has been well documented that the placenta represents a vital organ responsible for transporting nutrients and oxygen from mother to foetus and discharging waste from foetus to mother, which therefore takes up an important role in perinatal outcomes (Roland et al., 2012; Grigsby, 2016). Previous studies have affirmed a close relationship of placental weight with fetal intrauterine growth and birth weight (Fowden et al., 2008; Mando et al., 2014; Mohorovic, 2004; Soliman et al., 2013; Hutcheon et al., 2012). Meanwhile, exposure to specific air pollutants (e.g., from cigarette smoke) during pregnancy has been found to be associated with placental changes in terms of impairing placental structure and function (Niu et al., 2015), decreasing placental weight (Niu et al., 2015; Soto et al., 2017; Ghasemi-Tehrani et al., 2017; Rahmalia et al., 2012), size and surface areas (Soto et al., 2017), trophoblast volume (Milnerowicz-Nabzdyk et al., 2017) and the placental vascularization indexes (Hettfleisch et al., 2017), and increasing the odds (per 1-unit increase in exposure on the ln-scale) of fetal thrombotic vasculopathy (Wylie et al., 2017). In addition, several previous studies found that placental weight mediated a range of associations between maternal prenatal practices and fetal birth outcomes (e.g., the association of maternal pre-pregnancy body mass index (BMI), weight gain and gestational diabetes with fetal growth (Ouyang et al., 2013); the association between maternal second-hand smoke exposure during pregnancy and SGA (Niu et al., 2015); and the association of maternal exercise frequency during pregnancy with full-term LBW (Huang et al., 2017a) and preterm birth (Huang et al., 2017b)). Similarly, it is thus meaningful to test whether maternal exposure to COFs during pregnancy can damage the placenta and whether placenta also mediates the association between prenatal COF exposure and FT-LBW.

Based on the aforementioned findings, we make the following hypotheses: 1) maternal exposure to COFs during pregnancy may cause FT-LBW; 2) maternal exposure to COFs during pregnancy may damage placenta; and 3) placenta may mediate the association between prenatal COF exposure and FT-LBW. This case-control study thus aims to examine the three hypotheses.

2. Methods

2.1. Study design and subjects

A case-control study was undertaken from September 2009 to March 2011 at the Foshan and Shenzhen Women's and Children's Hospitals in Guangdong, Southern China. Mothers were enrolled within 12–36 h after delivery in the hospitals, if they delivered singleton and live babies at full term (37–42 weeks) and met the following inclusion criteria: a) aged 18 years or older; and b) had no obstetric complications (e.g., pre-eclampsia, antepartum hemorrhage, or placental abruption). Mothers with characteristics as follows were however excluded from the study: a) had one or more pre-existing chronic diseases, including renal disease, lung disease, diabetes, hypertension, hyperthyroidism, or anemia; b) had the history of preterm birth or habitual abortion; c) delivered macrosomic babies (birth weight > 4000 g); and (d) had missing information about placental weight and maternal COF exposure during pregnancy. Fig. 1 illustrates the detailed flow chart of our study participants.

The analytic sample size for this study was 1686 in total. Mothers who delivered full-term singleton live babies weighed less than 2500 g were categorised as full-term low birth weight (FT-LBW) cases (Indoor air pollution.), while otherwise those delivering normal-birth-weight (2,500-4000 g) infants at the same hospital were defined as full-term normal birth weight (FT-NBW) controls. This study was approved by the Institutional Review Board of the School of Public Health at Sun Yat-sen University, Guangzhou, China. All participants provided their informed consent.

2.2. Data collection

Each participating mother was invited to complete a structural questionnaire during a postnatal face-to-face interview, reporting information related to her socio-demographics, medical history, reproductive history, health-related behaviors, second hand smoke (SHS) exposure, and COF exposure during pregnancy. Medical records were further reviewed to retrieve participants' gestational medical and obstetrical information including medication, last menstrual date, early ultrasound assessment, parity newborn gender, birth weight, placental weight and insertion of umbilical cord.

2.3. Measurement of birth weight and placental weight

Birth weight was measured immediately after delivery by midwifery nurses. The placenta was measured fresh without membranes and large clots but with the cord trimmed. Both birth weight and placenta were measured on an electronic balance scale in decagrams to the nearest 10 g.