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Residential mobility during pregnancy in Urban Gansu, China

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ABSTRACT

Background: Studies on environmental exposures during pregnancy commonly use maternal residence at time of delivery, which may result in exposure misclassification and biased estimates of exposure and disease association. Studies on residential mobility during pregnancy are needed in various populations to aid studies of the environmental exposure and birth outcomes. However, there is still a lack of studies investigating residential mobility patterns in Asian populations.
Methods: We analyzed data from 10,542 pregnant women enrolled in a birth cohort study in Lanzhou, China (2010–2012), a major industrial city. Multivariate logistic regression was used to evaluate residential mobility patterns in relation to maternal complications and birth outcomes.
Results: Of the participants, 546 (5.2%) moved during pregnancy; among those who moved, 40.5%, 34.8%, and 24.7% moved during the first, second, and third trimester, respectively. Most movers (97.3%) moved once with a mean distance of 3.75 km (range: 1–109 km). More than half (66.1%) of the movers moved within 3 km, 13.9% moved 3–10 km, and 20.0% moved > 10 km. Pregnant women who were > 30 years or multiparous, or who had maternal complications were less likely to have moved during pregnancy. In addition, movers were less likely to deliver infants with birth defects, preterm births, and low birth weight.
Conclusions: Residential mobility was significantly associated with several maternal characteristics and complications during pregnancy. The study also showed a lower likelihood of adverse birth outcomes among movers than non-movers, suggesting that moving might be related to reduce exposure to environmental hazards. These results confirm the hypothesis that residential mobility may be important with respect to exposure misclassification and that this misclassification may vary by subpopulations.

1. Introduction

Studies examining the effect of environmental exposures on perinatal outcomes often rely on maternal residence at the time of delivery as a means of capturing the geographic location where women experience environmental exposures during pregnancy (Brauer et al., 2008; Bell and Belanger, 2012). This method has been used to assign such diverse environmental exposures as ambient air pollution (Brauer et al., 2008; Wilhelm, Ghosh et al., 2011; van den Hooven et al., 2012), water pollution (Winchester et al., 2009), heavy metals (Ahern et al., 2011), and chemicals (Langlois et al., 2009; Gemmill et al., 2013). Because information on where women reside at conception and during pregnancy prior to delivery is rarely available, such as in the commonly used birth certificate registries, researchers often use residential address at delivery as a proxy to determine environmental exposures during the entire pregnancy. Other methods of assessing environmental exposures,

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such as personal or household monitors and detailed diaries of geographic location, are often not feasible for studies due to the high costs of large cohorts.

The use of maternal residence at time of delivery as a proxy for environmental exposure throughout pregnancy may result in exposure misclassification and biased estimates of exposure and disease association (Miller et al., 2009; Bell and Belanger, 2012). Thus, understanding residential mobility of pregnant women is important for studies of environmental exposures and birth outcomes. The timing, frequency, and distance of movements would affect the extent of exposure misclassification (Bell and Belanger, 2012). Moving at later stage of pregnancy may lead to a larger degree of misclassification as compared to moving at earlier stage of pregnancy as studies often base exposure on residence at birth. A high frequency of moves (i.e., multiple moves during pregnancy) could be associated with elevated exposure misclassification. Although movements within short distances generally do not cause significant exposure misclassification, the misclassification could be substantial if the environmental pollutants having large spatial heterogeneity (Peng and Bell, 2010). The exposure misclassification could be differential if some segments of the study population have different moving patterns (e.g., are more likely to move than others) (Bentham, 1988; Bell and Belanger, 2012). The exposure misclassification could also be non-differential, potentially due to a short distance movement or very few people having moved in the study populations (Lupo et al., 2010; Chen et al., 2010). For these reasons, evidence on which subpopulations of pregnant women move during pregnancy and how moving patterns may differ is a critical research need.

Few studies have evaluated residential mobility during pregnancy, and these studies have only been conducted in European and North American populations (Khoury et al., 1988; GM and LH, 1992; Fell et al., 2004; Canfield et al., 2006; Hodgson et al., 2009; Chen et al., 2010; Lupo et al., 2010; Madsen et al., 2010; Tunstall et al., 2010). A similar pattern of residential mobility for both mothers who had neonates with adverse birth outcomes and mothers who delivered healthy babies was reported by several studies based on univariate analysis (GM and LH, 1992; Canfield et al., 2006; Lupo et al., 2010; Madsen et al., 2010). Maternal characteristics, including age, income, education, race, body mass index (BMI), and smoking, have been linked to residential mobility during pregnancy (Khoury et al., 1988; GM and LH, 1992; Fell et al., 2004; Canfield et al., 2006; Miller et al., 2009; Tunstall et al., 2010), indicating that residential mobility during pregnancy can differ by subpopulation characteristics that may influence associations between environmental exposures and birth outcomes.

Given the knowledge gap of residential mobility during pregnancy in Asian population and the lack of study investigating residential mobility patterns in relation to maternal complications, we analyzed data from a birth cohort in Lanzhou, China to examine the patterns of residential mobility during pregnancy, predictors of residential mobility, and potential relationship between residential mobility and birth outcomes.

2. Material and methods

2.1. Data collection

The cohort study design and data collection procedures have been described previously (Qiu et al., 2014). Briefly, a birth cohort was enrolled from February 2010 to December 2012 at the Gansu Provincial Maternity and Child Care Hospital (GPMCCH), the largest maternity and child care hospital in Lanzhou, Gansu, China. The 14,591 pregnant women who gave birth at the GPMCCH during this time period were eligible. A total of 10,542 women participated in the study (72% participation rate).

All study procedures were approved by the Human Investigation Committees at the GPMCCH and Yale University. Upon receiving signed consent from all participating women, an in-person interview was conducted by trained interviewers using a standardized structured questionnaire at the hospital. The questionnaire contained information on demographics, reproductive and medical history, smoking, alcohol consumption, physical activity, occupational and residential history, and dietary intake. Information on birth outcomes and maternal complications were abstracted from medical records.

Although the term "mobility" often refers to any change of permanent address (Douglas et al., 2005), here we use it to mean change of address at least once during the period from last menstrual period through delivery. Any woman with residential mobility during this time was considered to be a "mover". The data does not include information on the reason for the move or whether the move was permanent. The weeks of gestation at the time of the move were estimated as weeks between the date of last menstrual period and the date of move. The self-reported date of last menstrual period was verified by ultrasound measurement. First trimester was defined as weeks 1–12, second as weeks 13–27, and third from week 28 to delivery.

Maternal residential history, which included all addresses where the pregnant women lived during pregnancy, were collected from in-person interviews and were geocoded based on the Google earth engine (earthengine.google.com). Longitude and latitude coordinates were obtained for each subject's home addresses. The distance moved was defined as distance between current home address and previous home addresses and was calculated by using "geodist" function in SAS based on Vincenty's formulae (Vincenty, 1975).

Maternal covariates included age (< 25 years, 25–30 years, > 30 years), education level (≤9 years, 10–15 years, ≥16 years), employment status during pregnancy (yes/no), active and passive smoking (yes/no), parity (primiparous or multiparous), history of abortion (yes/no), and monthly household income per capita (< ¥1000, ¥1000–3000, > ¥3000). These characteristics were identified as predictors of residential mobility in previous studies. They are also important variables in studies of environmental exposure and birth outcomes. Complications during pregnancy were also considered, including preeclampsia, diabetes, anemia, thyroid disease, and gynecological complications (i.e., uterine abnormalities, ovarian abnormalities, infections of the vagina, cervix, uterus, and pelvic, and others). Because preeclampsia and gestational diabetes were diagnosed after 20 weeks of gestation, they were excluded from maternal complications in the analysis for those who moved in the 1st trimester. Fetus characteristics included multiple births and sex.

Birth outcomes included low birth weight, preterm birth, and birth defects. Birth defects were identified within 48 h after birth (down syndrome, polydactylia, digestive system defects, cleft palate, congenital heart defect, neural tube defect, male reproductive defects, and stillbirth). Birth weight was divided as < 2500 g, 2500–4000 g, and ≥ 4000 g (WHO, 2018). Preterm births (less than 37 completed gestational weeks) were further classified as moderate preterm (32–36 weeks) and very preterm (less than 32 weeks) (WHO, 2012).

2.2. Statistical analyses

Bivariate analyses were performed using chi-square tests for categorical variables and *t*-tests for continuous variables. Logistic regression models were used to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs). Factors associated with residential mobility were evaluated using multivariate logistic regression models. The associations between residential mobility and adverse birth outcomes were also examined by multivariate logistic regression models adjusting for maternal age, education, family income, passive and active smoking, parity, history of abortion, multiple births, and maternal complications. All tests were two-sided and assessed at the 0.05 level of significance. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).