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Birth history as a predictor of adverse birth outcomes: Evidence from state vital statistics data

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ABSTRACT

One of the most important predictors of preterm births (PTBs) or low-birth-weight births (LBWBs) is whether a mother has had a history of these birth outcomes. This study examined how different characterizations of birth history (e.g., any previous incidence of PTBs or LBWBs, immediate previous birth that was preterm or of low birth weight, and number of previous PTBs or LBWBs) were associated with PTBs or LBWBs. Based on birth records (n = 98,776) reported to the vital statistics electronic registration system in Nebraska from 2005 to 2014, mothers with a history of PTBs or LBWBs were more likely to have recurrences of these outcomes than those who did not have any history of PTBs or LBWBs. The adjusted odds ratios for recurrent PTBs ranged from 2.82 (95% CI: 2.62, 3.04) to 5.54 (95% CI: 4.67, 6.57) depending on how previous incidence of PTBs or LBWBs were characterized. The corresponding adjusted odds ratio for LBWBs ranged from 1.58 (95% CI: 1.43, 1.74) to 6.75 (95% CI: 4.96, 9.17). Relative to other measures used to characterize birth history, the use of number of previous PTBs or LBWBs allows for identifying mothers most vulnerable to recurrences of these birth outcomes. To help identify mothers at risk for future PTBs or LBWBs, it is beneficial to develop state-wide surveillance of reoccurrences for adverse birth outcomes which is feasible by integrating all separated birth records for the same mother using vital statistics data.

1. Introduction

Adverse birth outcomes, such as preterm births (PTBs, being born before the 37th week of gestation) and low-birthweight births (LBWBs, birthweight of fewer than 2500 g or 5.5 lbs.), is a significant public health issue in the United States. In 2015, about 1 in 10 newborns were preterm, and about 1 in 12 newborns were of low birthweight in the U.S. (Birthweight, 2017). These adverse birth outcomes represent the leading causes of infant mortality. Furthermore, infants who have low birthweight (LBW) or born before term are at increased risk for neurodevelopmental impairments and respiratory and gastrointestinal complications (Goldenberg et al., 2008). The annual economic burden due to these adverse birth outcomes was estimated to be more than $26 billion, which included the costs for immediate and long-term medical care, early intervention, and lost productivity due to disabling conditions (Butler & Behrman, 2007).

One of the most important predictors of PTBs is whether a mother had a PTB before the current pregnancy (Adams et al., 2000; Grantz et al., 2015). The recurrence risk of a preterm singleton delivery ranges from 16 to 30.2% (Goldenberg et al., 2008; van Zijl et al., 2016). Similar findings also hold true in the incidence of LBWBs. Mothers who had a history of delivering very LBWBs (less than 1500 g) were far more likely to have subsequent LBWBs (Bratton et al., 1996). Among mothers with two previous LBWBs, almost half had LBW recurrences in following deliveries (Barros et al., 2006; Sclowitz et al., 2013). These findings underscore the importance of using birth history to identify mothers at risk for adverse birth outcomes and to develop targeted interventions that address underlying risk factors if possible. Despite an extensive body of literature documenting risk factors associated with PTBs or LBWBs, few studies have focused on the repetitions of PTBs or LBWBs (Sclowitz & Santos, 2016), and how vital statistics data regularly collected by state governments can be used to monitor recurrences of

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these outcomes and identify mothers most vulnerable to these recurrences based on birth history.

In this study, we used population-based vital statistics data at the state level to assess the associations between previous incidence of PTBs or LBWBs and birth outcomes of the most recent pregnancy among mothers with complete birth history and at least two singleton births. In particular, we explored how different characterizations of birth history (e.g., any previous incidence of PTBs or LBWBs, immediate previous birth that was preterm or of LBW, and number of previous PTBs or LBWBs) were associated with PTBs or LBWBs with or without controlling for selected covariates. Based on our study findings, we discussed the feasibility and promise of establishing state-wide surveillance on recurrence of PTB or LBWB and how this surveillance system can help inform the design and implementation of interventions that seek to reduce recurrence of these adverse birth outcomes among vulnerable women.

2. Methods

2.1. Data

Data on birth outcomes and characteristics of mothers in the State of Nebraska for the period from 2005 to 2014 were collected from birth records reported to the vital statistics electronic registration system at the Nebraska Department of Health and Human Services. A mother index, a numeric code assigned to each unique mother in the dataset, was created so that multiple births from the same mother could be tracked over time. The probabilistic record linkage software LinkPlus 2.0 was utilized for a deduplication process to self-match mothers with multiple children (matching by a mother's first/last name, date of birth, and a unique identifier (such as the mathematical transformation of the mother's social security number, if available). This software was developed by the Centers for Disease Control and Prevention and was commonly used in detecting duplicative records or in linking health data from different sources. It automatically treats null or empty values as missing data and allows the user to indicate additional values to be treated as missing data (Centers for Disease Prevention and Control, n.d.). A matching score was selected as a cut off value to filter out mismatches, with a mismatch rate of less than 5% based on a quality check of 200 randomly selected records. Mothers without social security numbers were still matched on the other criteria; however, births from these mothers were less likely to be matched to other births in the dataset given their lower match scores.

Deliveries with birth weights less than 500 g or gestational age less than 22 weeks were excluded from the study sample. Additionally, any births that were out of the likely range of weight given their gestational age, based on Alexander et al.'s criteria, were removed (Alexander et al., 1996). Only singleton births were included in the dataset. Mothers with any non-singleton births or missing parities since 1995 (any parity less than maximum parity in the dataset for each mother) were removed from the dataset; records from 1995 to 2014 births of mothers in the sample were used to collect data on any previous birth outcomes to help create historical variables for the 2005–2014 births used in this study. The range 2005–2014 was selected because data for some important predictors were not collected before 2005. Births of first parity were ultimately removed from the final sample as they did not have historical data to predict birth outcome. The final study sample contained 98,776 singleton births of second parity or greater with complete, verifiable birth histories from 72,873 mothers.

2.2. Measurements

2.2.1. Outcomes

There were two dependent variables in this study. One was PTBs, defined as live births with a gestational age of fewer than 37 weeks. The other dependent variable was LBWBs, defined as births weighing less than 2500 g. While PTB and LBWB are closely correlated with each other, they are not identical. Some PTBs can still have normal birth weights, and some full-term births can result in low birth weight.

2.2.2. Historical predictors

In order to use previous birth outcomes as predictor variables, historical variables were created and fell into three general types, where each type had a separate variable for preterm birth and low birthweight (both of which had the same definition as the outcome variables): 1. Any previous PTB or LBWB, looking at any of a mother's births before her most recent birth (yes/no), 2. Immediate previous PTB or LBWB, the outcome of the birth that immediately preceded her most recent birth (yes/no), and 3. The number of previous PTBs and LBWBs (0, 1, or 2 or more).

2.2.3. Control variables

Since birth records from 2005 to 2014 were used in the analysis, a categorical variable "Birth Year" was created to denote the period in which the baby was born (2005–2009 or 2010–2014). Mother's demographics were characterized by age (< 18 years, 18–35 years, or 36 + years), race/ethnicity (Hispanic, or non-Hispanic (NH) White, NH Black, NH Asian, NH Native American, or NH Other), marital status (married or unmarried), and urban or rural residence based on the county where the mother lived.

Two variables were related to mother's economic status. One was mother's education (< 12 years, high school degree, some college, or college degree or above). The other variable was mother's health insurance coverage at birth (Medicaid, private, self-pay, or other).

Several variables were used to characterize mother's health or health behavior before or during pregnancy, including pre-pregnancy BMI (underweight, normal weight, overweight, or obese), pre-pregnancy diabetes (yes or no), chronic hypertension (yes or no), tobacco use during pregnancy, pregnancy induced diabetes (yes or no), and pregnancy-associated hypertension (yes or no). We also included variables on whether birth was delivered through C-section, parity (2, 3, or 4 or above), and birth interval (18 months or less vs. 19 months or longer).

2.3. Statistical analysis

Frequencies and percentages of all variables used in the analysis were calculated. Cross-tabulations were generated, and chi-square tests were calculated to assess the associations between each of the six birth history variables and PTBs or LBWBs. Generalized estimating equations (GEE) were used to determine the odds of PTBs or LBWBs based on history of PTBs or LBWBs with (adjusted odds ratio) or without (unadjusted odds ratio) controlling for the effect of selected variables on mother's demographics, SES, health, and health behavior before or during pregnancy, C-section use, parity, and birth interval.

The GEE models in our analysis used alternating logistic regressions with exchangeable log odds ratios to account for the repeated observations from mothers with more than one birth represented in the dataset (Carey et al., 1993). Areas under the Receiver Operating Characteristic (ROC) curve (AUC), along with Quasi-likelihood under the Independence Model Criteria (QICu), were used to compare prediction between different models. All statistical analyses were run using SAS software version 9.4 (SAS Institute Inc., 2013), and p-values less than < 0.05 were considered statistically significant.

3. Results

The frequency distribution of all the variables used in the analysis is listed in Table 1. Regarding the two dependent variables, 7.9% of singleton births in the sample were PTBs, and 3.7% were LBWBs.

About 8.4% of the current or most recent births in the sample were immediately preceded by a PTB, whereas 4.8% were immediately