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# Understanding Weather, Climate, and Birthweight: Findings from the U.S. Natility Data Files 1969-78

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# Understanding Weather, Climate, and Birthweight: Findings from the U.S. Natility Data Files 1969-78

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*Abstract*—**Weather and extreme weather events are thought to be related to low birth weight. If this relation is held, it will have a wide range of public health impacts as birth weight is a key indicator of many life course health outcomes, and climate change increases the intensity of extreme weather events. The current study examines the relationship between birth weight and weather variables during the birth month while controlling other known risk factors. While the preliminary results seem to suggest a relationship between birth weight and extreme hot temperature, the result does not hold when individual and other risk factors are introduced. It is concluded that birth weight is primarily related to the temperature of birth month: the colder the month, the heavier the baby, to some degree. Even though we did not confirm the relationship between birth weight and extreme weather events, global warming is still likely to negatively affect birth outcomes.**

***Keywords-birth weight; ambient temperature, weather, extreme temperature days***

## I. INTRODUCTION

Birth weight is a key health indicator, and it has paramount impacts on infant and late life health outcomes. The influence of ambient temperature on birth weight has been extensively studied (Strand et al. 2001). Ambient temperature extremes, especially excessive heat, inhibit both fetal growth and gestation. Pregnancy exacerbates heat stress through increased fat deposition and decreased heat regulation function. Pregnant mothers are more susceptible to extreme heat and cold stress, and both excessive low birth weight and preterm births are often found in summer and winter seasons. As climate change will increase the intensity and frequencies of extreme weather, it is likely to adversely affect birth outcomes. Recently, Deschênes et al (2009) investigated low birth weight among U.S. counties from 1972 and 1988 using the Nadality Detail Files (NDFs). They found an inverse relationship between birth weight and the number of days of exposed to high temperature (defined as over 85oF daily average) during each trimester, and the effects become stronger during the second and third trimesters. They concluded that global warming with increased extreme hot days will increase low birth weight babies.

However, it is not clear, whether the effect was due to extreme weather, climate or seasonal climatic patterns, as all of these factors have been related to birth weight. In addition, the fact that higher temperature days are positively associated with all three trimesters found in Deschênes et al, suggests a geographic or climate effect across temperature zones in the US. Furthermore, factors, such as parity, education or income have rarely been taken into account in previous climate- and seasonality-birth weight studies. In this paper, we reinvestigate both temperature and extreme weather effects on birth weight across US counties using the 1969 to 1978 Natality Data Files (NDFs). We controlled most known individual factors, such as sex, parity, and mother's age and education. We found an inverse relationship between birth weight and mean temperature, but found no relationship between birth weight and the number of hot days for the general population with or without controlling for the mother's educational level.

## II. METHOD

### *A.Data*

We chose the U.S. Center for Disease Control and Prevention (CDC) Natality Data Files of 1969 to 1978 because of their wide geographical coverage and relatively rich information about the mother. The U.S. NDFs formally launched in 1968 that required states to submit individual birth certificates data to CDC. The CDC then made them publically available from 1968 to 1988 at the county level, and the birth data since 1988 have only been available for counties with a population of at least 100,000. This data release schedule fits our purpose, as we attempted to choose birth years as early as possible, so that we could capture extreme weather or other temperature effects when people had relatively few coping options. According to the literature and the US census data of 1970, central air conditioning only became popular in the late 1960s for new homes, while the majority of homes were still without air conditioning units, especially central air units (Lin et al 2007). Hence, late 60s and early 70s data in the United States provide a "nature experiment ground" of pregnancy and in-utero babies' responses to weather and climatic conditions. It is our understanding that such a dataset is not publically available at a continental scale in other countries.

The ten year files contain over 23 million birth records. In early years from 1969 to 1972, about 20 state only submitted 50% records, and in 1978, all states submitted the 100% birth records to the CDC. We restricted our samples to 48 continental states and the District of Columbia in United States. From these state files, we first created a 50% sample file of the U.S. births by deleting 50% random samples from states that had a 100% sample. We then randomly selected a 2% sample, which is equivalent to a 1% birth sample for the entire 48 continental states and the District of Columbia in United States from 1969 to 1978. In order to have the widest geographic coverage with a pure racial effect, we chose only Whites or Caucasians according to the race of mother on the birth certificate. Blacks and other races were excluded because blacks tend to have low birth weight and they had a geographically skewed distribution. We first selected live singleton births, and excluded all the twins or multiple births. We found that three years between 1969 and 1972 did not have a singleton birth indicator. We also found that there were less than 1% multiple births, and about 50% of babies from the multiple births had low birth weight, or <2,500kg. In addition, they were distributed almost evenly by states and by geographic regions. We, therefore, used all the birth data that included multiple births. The final sample size was 269,511.

*C. Control variables*

We attempted to control some of the known factors. We used the age squared of the mother to control for the evident bell shape effect, because both early and late pregnancies tend to have a lower birth weight baby. We contrasted a first birth with other births, and male births versus female births, because birth weight is greater for males than for females, and greater for subsequent births than for the first births (Kramer 1987; Matsuda 1995). We did not include marital status as the preliminary result failed to show its significance. Gestation period was not included, as it is part of the outcomes affected by weather.

In addition, we controlled for the mother's educational level or other income related effects. Due to the fact that the birth certificates did not have income, and mother's education only became available after 1975 for the majority of states, we used two strategies to account for income. We first used county per capita income from1969 to 1978 to provide a contextual effect for the entire U.S. Then we used the mother's educational level for States east or adjacent to the Mississippi River in 1976 to 1978, because these states had the complete coverage of the educational variable. A mother's educational level was divided into two categories, those with high school or higher versus those without high school diplomas.

We also included the average elevation of a county as it showed a negative effect on birth weight (Jensen & Moore, 1997). In particular, we created two variables: One was an indicator variable contrasting the average elevation 1,500 meters above versus below the sea level, and the other was simply the average elevation. Both variables were derived from the National Elevation Data in grid from the US geological survey (Lin, et al. 2007).

*D. Weather variables*

We included a number of weather and climate variables. We followed primarily Deschênes et al.(2009) and used the National Climatic Data Center Summary of the Day Data (File TD-3200). We used the population center point for each county according to the US census and matched it with the nearest weather station available. We found there was only 1 county without station data, and we used the station from the nearest county. Since station level data for those years did not have humidity, we used various combinations of temperature variables. First, we created all the variables used in Deschênes et al. (2009) which includes county's daily averages temperature in the following bins: < 25°F, 25° - 45°F, 45° - 65°F, 65° - 85°F, > 85°F. We then added additional extreme weather variables, such as daily maximum temperature >90°F, > 95°F or a daily minimum <20°F (see Lin et al 2007 for some justifications of temperature variables).

Finally, we added temperature measures for the month immediately before the birth for these temperature measures. However, we did not include weather data for the inception month as about 50% of data in the sample years did not have a valid inception date that could be derived either from the last menopause date or from gestation periods.

*E. Statistical Analysis*

We used an ordinary least squares (OLS) regression to relate birth weight to other variables. The dependent variable is birth weight in grams. Independent variables include mother's age, and educational level, baby's sex, birth order, the log of county income each year, county elevation, and a set of temperature variables. The key weather indicators had 372,000 (10 years*12 months * 3100 counties) data points over the 10 years period, which is greater than the 269,511 sample observations. For this reason, the OLS regression is appropriate. We used a stepwise regression in the model selection for the overall model which covers the entire 48 states. When an inflation factor was greater than 2 for two variables, we deleted one of them with the highest inflation value. We used the same model selection strategy by adding mother's educational level for states that had complete educational variables after 1975 (Figure 1). Again, once the model was selected, we also added an extreme weather variable just to show its significant level.

## III. Results

Figure 1, which is based on the full sample of 23 million records, presents mean birth weight for Caucasians in the study period. There was a general geographic tendency toward a low mean birth weight from north to south, and it was mixed with some regional patterns. Minnesota, Wisconsin and Iowa often observed severe winter storms, but they tended to associate with high birth weight. A swath of countries in the Census Mountain region, however, had a relatively low mean birth weight. The main reason for this regional effect was likely to relate to elevation, as the region sits on the mountainous areas in the Census Mountain Region, where weather could be more volatile. This region together with the Southwest region (e.g., Oklahoma, Arkansas and Texas) suggests both relative hot temperatures and more extreme weather events might affect birth weight. The geographical patterns of mean birth weight are almost identical for male and female births (not shown).

Before conducting the formal modeling exercise, we replicated the previous study (Deschênes et al 2009) by using the same regression framework. We found that the number of days with "extreme" weather, either measured as >85oF average, or >90oF daily maximum were significantly related to lower birth weight. However, after we included individual risk factors and competing temperature variables, the results did not hold up.

TABLE I. RESULTS FROM OLS REGRESSIONS ON BIRTH WEIGHT

MODEL I ALL 48 STATES

| | Coeff | T-value | P-value |
|---|---|---|---|
| Intercept | 7.97986 | 746.66 | <.0001 |
| Log Income | 0.01018 | 7.81 | <.0001 |
| Male | 0.03622 | 45.5 | <.0001 |
| First birth | -0.01291 | -14.8 | <.0001 |
| Age squared | 0.00436 | 18.03 | <.0001 |
| Elevation > 1500m | -0.04637 | -16.39 | <.0001 |
| Days Avg T < 25 | 0.00034324 | 3.95 | <.0001 |
| 25<Days Avg T < 45 | 0.00028083 | 5.46 | <.0001 |
| Days Max T >90 | -0.00003794 | -0.49 | 0.6215 |

MODEL II EASTERN STATES WITH EDUCATIONAL VARIABLE

| | Coeff | T-value | P-value |
|---|---|---|---|
| Intercept | 8.05383 | 1766.05 | <.0001 |
| Male | 0.03695 | 20.27 | <.0001 |
| First birth | -0.01822 | -9.2 | <.0001 |
| Age squared | 0.00293 | 4.91 | <.0001 |
| High School | 0.0421 | 19.24 | <.0001 |
| Average elevation | 0.00001198 | 2.13 | 0.0333 |
| Ave Monthly Temp | -0.00014922 | -2.33 | 0.0199 |
| 25<Days Avg T < 45 | 0.00018475 | 1.56 | 0.1176 |
| Days Max T >90 | 0.0001684 | 0.67 | 0.5007 |

The results for the 48 states (the upper panel of Table I) showed that birth weight primarily related to individual factors, such as age, sex and birth order. Male babies tended to be heavier than female babies, and those born as second or third child etc. tended to be heavier than the first born. Mother's age had a bell shaped effect, where early and late age pregnancies were associated with low birth weight. In addition, area income without controlling for individual education tended to be positively related to birth weight. Area elevation was also significant. Comparing to counties with an average elevation below 1,500 meters, counties above this level were associated with lower birth weight. This effect was stronger than the effect from the average elevation variable. Since both were correlated, only the stronger effect was retained.

After controlling for these individual effects, we found that birth weight was only related to two temperature measures. It was positively related to the number of days colder than 25oF, and in the temperature range of 25oF and 45oF during the birth month. Note that we forced the number of days > 90oF (or other temperature variables) into the equation, and the result was not significant.

The results from Model II (the lower panel of Table I) that included the educational variable for states near or eastern the Mississippi river were broadly consistent with those from model I. However, the high altitude effect, that was significant in Model I, was not significant, because elevations near or east of the Mississippi river were rarely above 1,500 meters. Instead, the average elevation as a continuous variable was positively related to birth weight. Controlling for these effects, we found that educational level was very significant; mothers who had a high school education or above tended to have a heavier baby comparing those without a high school education. It turned out that the average monthly temperature during the birth month became significant, the colder the temperature, the heavier the baby. Again, the number of >90oF days was not significant.

## IV. DISCUSSION

In this study, we have provided an empirical analysis of birth weight and its relationship with a set of temperature measures. Without other individual variables, such as mother's age, and parity, we found the same relationship identified by the previous investigations in that extreme weather conditions might have a negative effect on birth weight. However, after controlling for individual and other risk factors, extreme temperature effects were replaced by general weather or climate variables. In general, either the average temperature of birth month, or the number of days in the temperature bins of <25oF, or 25-45oF tended to be positively related to birth weight. Days with extreme temperature do not have an additional effect after controlling for these stronger temperature effects.

This study has a number of limitations. First, the humidity is not available, and therefore, we cannot generate the heat index that combines temperature and humidity. Second, we did not have many geographical variables. The one we included was elevation, and its effect was fairly strong. Ideally, we could have separate analyses for each distinct region. For instance, the low-birth weight region that covers Wyoming, Colorado, and New Mexico seems to have more to do with elevation than with temperature. However, the area also has mountainous weather with a great deal of volatility. Third, even though the number of temperature data points of 372,000 were greater than the number of sample observations of 269,511, a mixture model might be better for a county with a lot of sampled birth within a month.

However, since we did not find extreme weather effects, a mixture model is unlikely to uncover these potential effects.

It is concluded that birth weight is primarily related to the temperature of birth month: the colder the month, the heavier the baby, to a degree. This effect incorporates seasonality and climatic effects, but it may not necessarily be related to daily weather conditions, such as the number of >90oF days during the birth month. Even though we did not find the relationship between birth weight and extreme weather events, global warming is still likely to negatively affect birth outcomes. As the future climate becomes warmer, people will have more low birth weight babies, all else being equal.

## REFERENCE:


[1] Strand LB, Barnett AG, Tong S, "The influence of season and ambient temperature on birth outcomes: A review of the epidemiological literature," Environ. Res. (2011), doi:10.1016/j.envres.2011.01.023

[2] Deschênes, O. Greenston, M. and J. Guryan, "Climate change and birth weight," American Economic Review, 2009, 97(2): 211-217.

[3] Jensen. GM and Moore.LG, "The effect of high altitude and other risk factors on birthweight: independent or interactive effects?" Public Health. 1997 June; 87(6): 1003–1007.

[4] Kramer, M.S. 1987. Determinants of Low Birth Weight: Methodological Assessment and Meta-analysis. Bull. WHO 65:663-737.

[5] Matsuda S, Hiroshige Y, Furuta M, Doi T, Sone T, Kahyo H. 1995. "Geographic differences in seasonal variation of mean birth weight in Japan," Hum Biol. 1995 Aug;67(4):641-56.

[6] Lin, G. Spann, S. Hyman, D. Povlik, V. 2007, "Climate amenity during off-work hours and body mass index," Obesity Research 15:2120-2127.


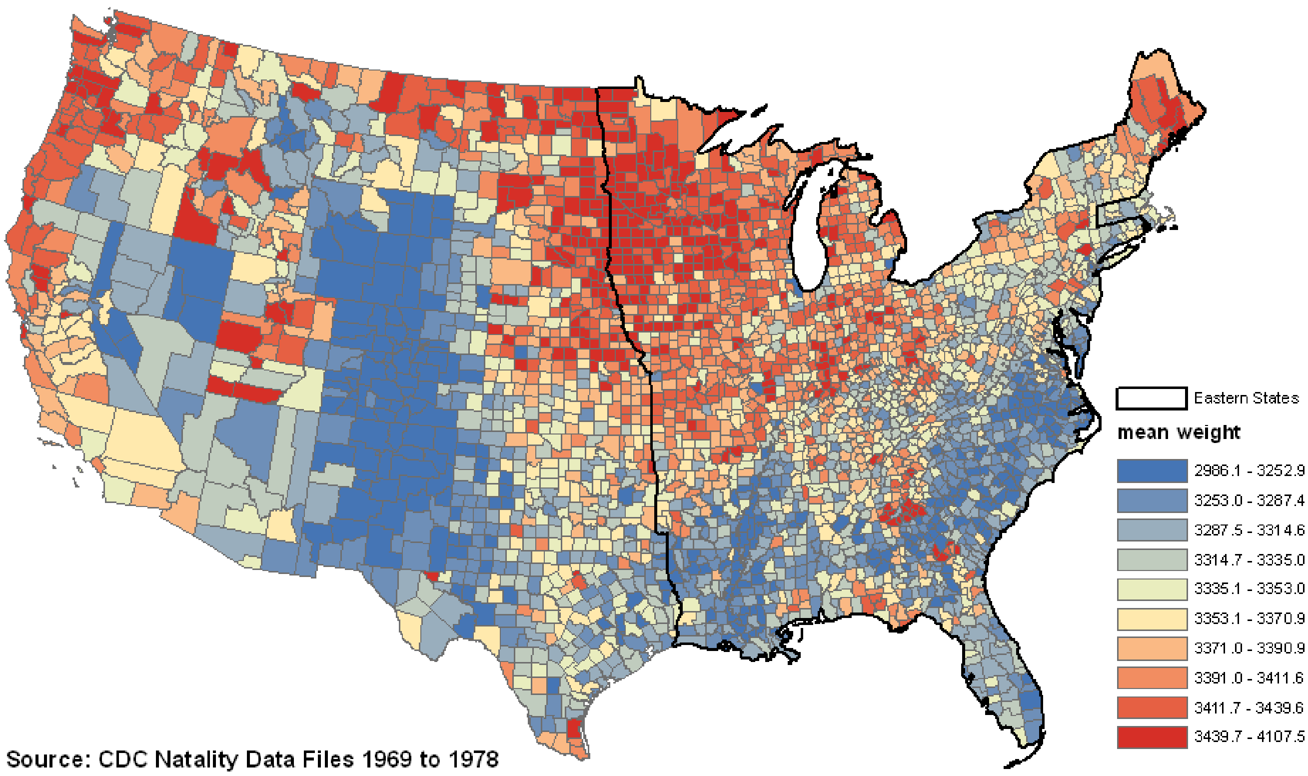


Figure1. Average birth weight for Whites by county in the United States: 1969 to 1978