Spring 2022

Assessing Birth Outcomes Resulting from the Franklin County Model

Lane A. Simsarian

Assessing Birth Outcomes Resulting from the Franklin County Model

Lane A. Simsarian, BA, MPH Candidate
January 25, 2022

Introduction

The United States' preterm birth rate is one of the highest among high-resource countries (*Fighting premature birth: The prematurity campaign* 2021). Approximately 1 in 10 babies in the US is born preterm (*Preterm birth* 2021). There are few comprehensive community-wide interventions focused on birth outcomes and cardiovascular risk reduction.

Franklin County in Maine implemented an integrated, community-level cardiovascular risk reduction program in the 1970s. This community-level intervention focused on improving the health systems (infrastructure, access, and quality), reducing risk factors (hypertension, cholesterol, and diabetes), and improving health behaviors (tobacco cessation, healthy diet, and physical activity) (Record et al., 2015). The researchers' analysis consisted of aggregating Maine data at the county level and then comparing Franklin County to the other Maine counties. Franklin County's community-wide intervention targeting cardiovascular risk reduction centered on reducing hospitalizations and mortality rates. They found that Maine hospitalization rates were strongly associated with household income, yielding an R^2 of 0.72 and a p-value of <0.001 (Record et al., 2015). Franklin County's hospitalization rate was found to be significantly lower than what was predicted by household income, with 17 fewer hospitalizations per 1000 population in Franklin county than would be expected given household income (Record et al., 2015). Analyses were conducted to determine the benefits of population-wide interventions in reducing risk factors and improving health.

A more recent study conducted by some of the same researchers assessed mortality and smoking rates prior to and after the Franklin County Model. The goal was to determine upon completion of a community-wide intervention focused on reducing risk factors and improving health how sustainable the effects were. The researchers conducted linear regression and analysis of variance on age-adjusted mortality versus median household income, smoking vs income and county health rankings (CHR) health outcomes vs SES (Onion et al., 2019). They found that improved health outcomes decreased as intervention actions were reduced. During the period 1996 to 2000, Franklin's income-adjusted smoking rates were an outlier in Maine, with a t-score of -3.31 (indicating lower than expected smoking rates given median household income), but by 2011 to 2015 results were similar to the predicted rates, with a t-score of -0.33 (indicated expected rates) (Onion et al., 2019). The study also found that comparing expected health outcomes such as mortality against median household incomes by county may provide a better, more effective way to identify and monitor rural population health than comparing county outcomes to the state average (Onion et al., 2019).

The purpose of this Capstone project was to examine the effects of the Franklin County community-level intervention model with a focus on the birth outcomes of low birth weight and preterm births. Low birth weight is defined as a newborn weighing less than 2,500 grams (5 pounds and 8 ounces) (*FastStats - Birthweight* 2021). Preterm birth is a newborn born before 37 completed weeks of pregnancy (*Preterm birth* 2021). Previous evaluations suggest that the Franklin County Model did have a positive effect on cardiovascular health outcomes at the population level, but the effect it had on birth outcomes is unknown. This study estimated the effects of a community level intervention on birth outcomes by examining births from Franklin County, Maine during 1970-1988.

Methods

Birth certificate data were retrieved and downloaded from the publicly available National Bureau of Economic Research website and income data from the United States Census Bureau's historical income tables. Nineteen years of birth certificate data were imported into SAS 9.4 and restricted to the state of Maine. Variables were recoded and harmonized over time as data fields collected changed over the years.

Outcome Variables (Low Birth Weight and Preterm Births)

First, recoding of the data was needed to properly run analyses. Maine years 1970 and 1971 were doubled in weight since only 50% of births in Maine were reported for these years. Gestational age was recoded to preterm with "1" representing 20-37 gestational weeks and "2" representing 37-52 gestational weeks. Birthweight was recoded to low birth weight (LBW) with "1" representing 0-2,500 grams and "2" representing 2,500-8,165 grams.

Approximately 15.93% of births were missing gestational age. Missing gestational age accounted for coding "0" and "99." Additionally, due to viability reasons less than 17 weeks and weeks greater than 44 were considered missing which added an additional 2.27% missing. Women that carry the fetus for more than 44 weeks run into post-pregnancy complications and women who have pregnancies longer than 44 weeks account for a very small subset of the population (Galal et al., 2012). For both scenarios, we imputed gestational age as follows. For the births missing day of last menstrual period only (with non-missing month and year of last menstrual period), we first accounted for leap years. February leap years occurred in years 1968, 1972, 1974, 1980, 1984, and 1988. We recoded and adjusted for the leap year month dates through changing days to account for the specific leap years to accurately capture last menstrual period dates. Additionally, we imputed the 15th of the month, allowing for calculation of gestational age. For the births missing month and/or year of last menstrual period, we used birthweight to impute gestational age using published formulas for singleton births by sex (Aris et. al., 2019).

Predictor Variable (Median Household Income)

County-specific Maine median household income data was downloaded from United States Census Bureau's historical income tables and merged with aggregated birth certificate data by county and year (*Income data tables* 2021). Median household income data was only available in 10-year increments. To break down these into single-year estimates, we used simple linear interpolation.

Data Analysis

A linear regression model was used to estimate the association between median household income, as a measure of SES, and low birth weight and preterm births, separately, to see if Franklin County had lower-than-expected rates of these birth outcomes as compared to the rest of Maine. The analysis mirrored Dr. Onion and Dr. Prior's research (Onion, et. al., 2019). Low birth weights and preterm births were compared to household income in Maine counties by 1-year and rolling 5-year intervals.

Sensitivity Analyses

Linear regression analysis was repeated after restricting to birth certificate data on first-born singletons, and (separately) restricting to birth data with non-missing gestational age. The first sensitivity analysis was done because plurality and birth order are associated with low birth weight and preterm births, and changed over time and by county, which could have confounded our results. The second sensitivity analysis (a "complete case analysis") was done to assess the impact of our method for imputing missing gestational age.

Results

There were 311,737 births included in this analysis, with 17750 births in 1970 and 17172 births in 1988; approximately 2.29% of all births in Maine were in Franklin County each year (Figure 1).

Preliminary analyses were conducted to describe trends during 1970-1988 by county for each birth outcome. Line charts were created to show to trends of low birth weight percent and preterm birth percent for counties, paying particular attention to Franklin County as this was the focus point of the research. Both charts show a small negative slope (0.0005 decrease per year for low birth weight; 0.0007 decrease per year for preterm birth) from year 1970-1988 (Figures 2 and 3). In additional to single line graphs, a sixteen -line graph was created to show all counties in Maine during this time period (Figures 4 and 5).

Linear regressions for years 1970-1988 using median household income as the predictor variable and preterm birth as the outcome variable showed no statistical association. Of the eighteen years analyzed at one-year intervals, no global p-value or Spearman p-value reached statistical significance (all p-values > 0.05) (Supplemental Table 1). Spearman's correlation coefficient is a nonparametric statistic that is helpful to minimize the effects of violated assumptions. We used this statistic because all assumptions were not met such as a low n values. Linear regressions for median household income and low birth weight births from 1970-1988 as well showed no statistical association (all p-values > 0.05) (Supplemental Table 2).

Sensitivity analyses using birth certificate data for first and singleton births (*n*=415869) only showed years 1976, 1981, 1982, 1987 reaching statistical significance for the outcome of preterm birth (Supplemental Tables 3). The corresponding slopes (preterm birth change per $1,000 increase in median household income) for these models were: -0.0058, -0.0047, -0.0041, and -0.0035. No statistically significant associations were found for the sensitivity analysis with low birth weights versus median household income (Supplemental Table 4).

The complete case analysis excluded all missing data in hopes to reduce biases that may occur in analyses (*n*= 237408). For both preterm births and low birth weight births, no years reached statistical significance for the global p-value or Spearman's p-value (Supplemental Tables 5 and 6).

Rolling five-year intervals showed that Franklin county did not necessarily have better birth outcomes given median household income in comparison to all other Maine counties (Tables 1 and 2). Negative T-scores represent better outcomes (i.e. lower preterm birth) than predicted by median household income. Only one T-score for Franklin County had a negative value which was for preterm births from 1979-1983, but the p-value was not statistically significant (T-score= -0.305; p-value= 0.3823). Both preterm births and low birth weight rates were not significantly associated with median household income for any of the five-year interval periods (Figures 6-11).

Discussion

Both one-year and five-year intervals for preterm births and low birth weight births were not associated with median household income for Maine during 1970-1988. This prohibited us from making confident conclusions regarding the effects the Franklin County Model had on birth outcomes for these birth years. As previously discussed, not many studies have been conducted to assess the birth outcomes related to community-level, integrated interventions such as Franklin county.

Previous research suggested that the Franklin County model resulted in reduced hospitalization and mortality rates over a 40-year period as compared to other Maine counties (Onion et al., 2015). Given the lack of statistical associations from the linear regression analyses we conducted, we can't conclude that the Franklin County model had an effect on birth outcomes as well.

However, it is plausible that reducing cardiovascular disease prevalence can improve birth outcomes. The general historical trends of smoking, a main cause of cardiovascular disease, has been on the decline since the public awareness of the health effects. Before 1964, tobacco use was increasing alongside cardiovascular diseases; once tobacco use and its related health effects became more well known, there was a decline in cigarette use due to public awareness, regulations, and taxes (Cummings & Proctor, 2014). Results from our study showed reductions in low birth weight and preterm birth rates during 1970-1988, a small decline through the years which could potentially be attributed to decreases in cigarette smoking. We could not look into smoking rates at the individual nor county level during these study years due to lack of available data.

Limitations

When working with group level data there is always a chance of an ecological fallacy occurring. An ecological fallacy is when there are inferences made about individuals that are based on group level, aggregated data (Hsieh, 2017). As such, given that this study used aggregated, county-level data, there may actually be associations between household income and birth outcomes at the individual level that are not detected in the current results. Individual data may provide more insight into how birth outcomes are related to community-wide cardiovascular risk reduction interventions.

Data were only gathered from 1969-1988 due to changes in the birth certificate beginning in 1989. Starting at 1989 county residence was only identified if there were over 100,000 individuals in the population. Since Maine has many low-population counties, including Franklin county, we had to restrict our analysis to 1970-1988. With restricted use birth certificate data, counties lower than 100,000 people would have been able to been identified. Another limitation of the analysis was the income data. The only publicly available historical household income data was in intervals of ten years; therefore, a simple interpolation equation was used to compute median household income per year. As such, there could be errors in the computed household incomes if some years did not have the same rate of increase

Implication & Further Research

There is still little research related to birth outcomes resulting from community-level interventions. Though our analysis did not find anything conclusive, it does not mean this intervention did not have an effect at the individual level. Further research should be conducted using individual, nonaggregate data and incorporate other factors related to socioeconomic status and cardiovascular health such as education, employment and smoking.

Further research should be conducted in other areas of the United States that are more diverse than Maine. The effects could potentially yield different results due to differing demographic characteristics of states.

Conclusion

Our analysis did not find conclusive results regarding the effect of the Franklin County model on birth outcomes. More research can be conducted on the Franklin County model to assess birth-related outcomes at the individual level. Additional research also should be conducted on other community-level interventions and the effects they had on birth outcomes as there is little literature exploring these topics.

References

Aris, I. M., Kleinman, K. P., Belfort, M. B., Kaimal, A., & Oken, E. (2019). A 2017 US Reference for Singleton Birth Weight Percentiles Using Obstetric Estimates of Gestation. *Pediatrics*, *144*(1), e20190076. https://doi.org/10.1542/peds.2019-0076

Centers for Disease Control and Prevention. (2021, March 2). *FastStats - Birthweight*. Centers for Disease Control and Prevention. Retrieved October 11, 2021, from https://www.cdc.gov/nchs/fastats/birthweight.htm.

Cummings, K. M., & Proctor, R. N. (2014). The changing public image of smoking in the United States: 1964-2014. *Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology*, *23*(1), 32–36. https://doi.org/10.1158/1055-9965.EPI-13-0798

Fighting premature birth: The prematurity campaign. Home. (2021). Retrieved October 11, 2021, from https://www.marchofdimes.org/mission/prematurity-campaign.aspx.

Galal, M., Symonds, I., Murray, H., Petraglia, F., & Smith, R. (2012). Postterm pregnancy. *Facts, views & vision in ObGyn*, *4*(3), 175–187.

Harville, E. W., Myers, L., Shu, T., Wallace, M. E., & Bazzano, L. A. (2018). Pre-pregnancy cardiovascular risk factors and racial disparities in birth outcomes: the Bogalusa Heart Study. *BMC pregnancy and childbirth*, *18*(1), 339. https://doi.org/10.1186/s12884-018-1959-y

Hsieh, J. J. (2017, September 4). ecological fallacy. Encyclopedia Britannica. https://www.britannica.com/science/ecological-fallacy

Onion, D. K., Prior, R. E., Record, N. B., Record, S. S., Cayer, G. R., Amos, C. I., & Pearson, T. A. (2019). Assessment of Mortality and Smoking Rates Before and After Reduction in Community-wide Prevention Programs in Rural Maine. *JAMA network open*, *2*(6), e195877. https://doi.org/10.1001/jamanetworkopen.2019.5877

Record, N. B., Onion, D. K., Prior, R. E., Dixon, D. C., Record, S. S., Fowler, F. L., Cayer, G. R., Amos, C. I., & Pearson, T. A. (2015). Community-wide cardiovascular disease prevention programs and health outcomes in a rural county, 1970-2010. *JAMA*, *313*(2), 147–155. https://doi.org/10.1001/jama.2014.16969

World Health Organization. (2021). *Preterm birth*. World Health Organization. Retrieved October 11, 2021, from https://www.who.int/news-room/fact-sheets/detail/preterm-birth

US Census Bureau. (2021, November 21). *Income data tables*. Census.gov. Retrieved November 27, 2021, from https://www.census.gov/topics/income-poverty/income/data/tables.html.

Figures and Tables

Figure 1: Percent of Babies Born per County and in Franklin County from 1970-1988

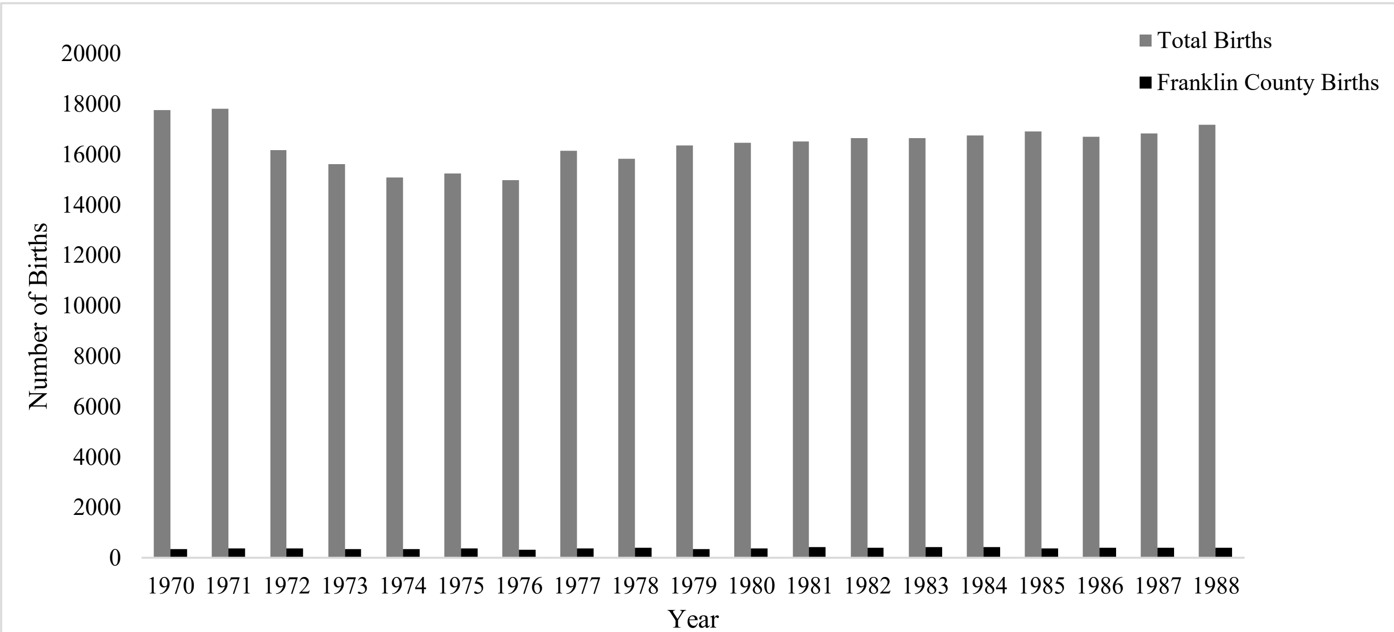

Figure 2: Percent of Babies Born Preterm in Franklin County from 1970-1988

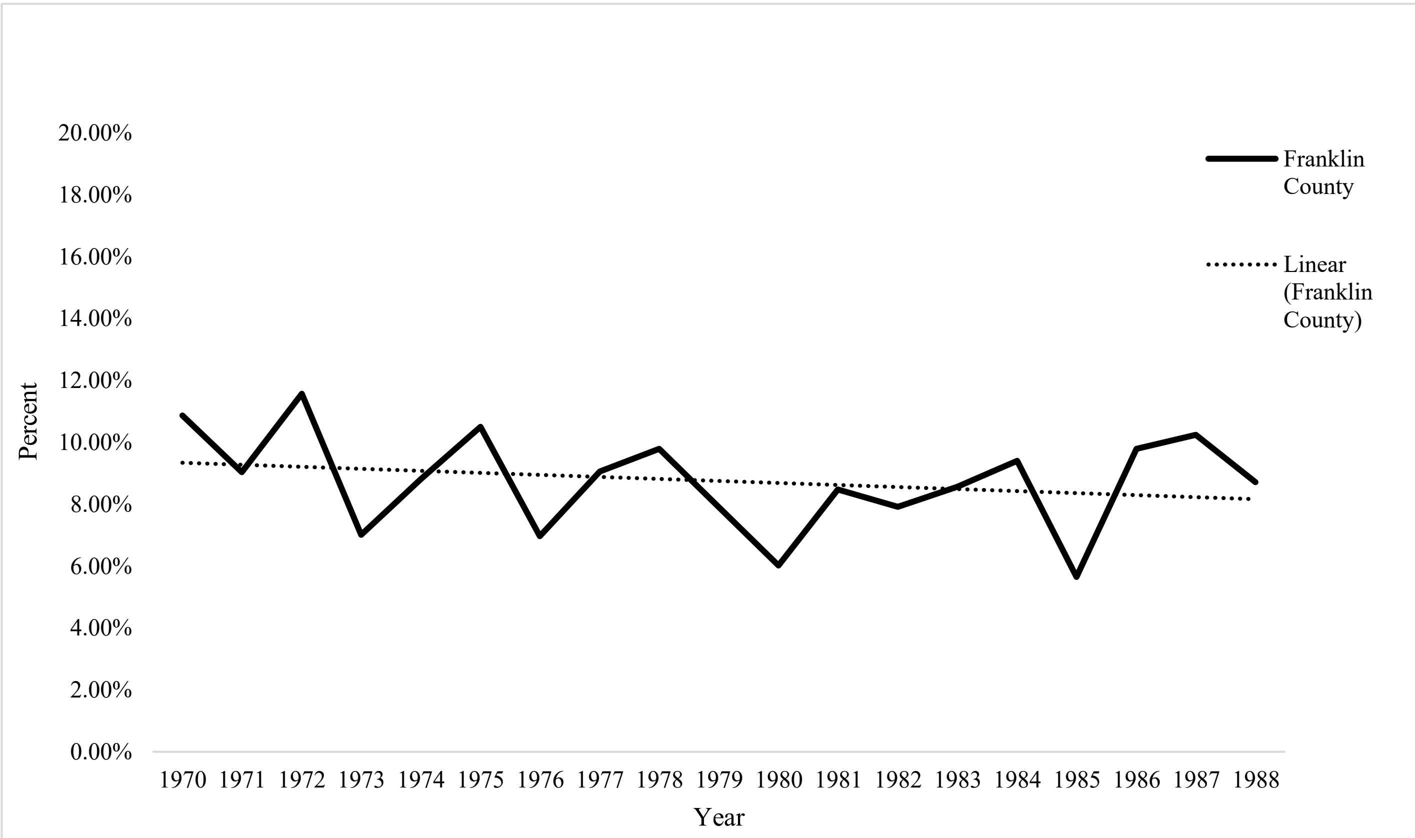

Figure 3: Percent of Babies Born in Franklin County with Low Birth Weight From 1970-1988

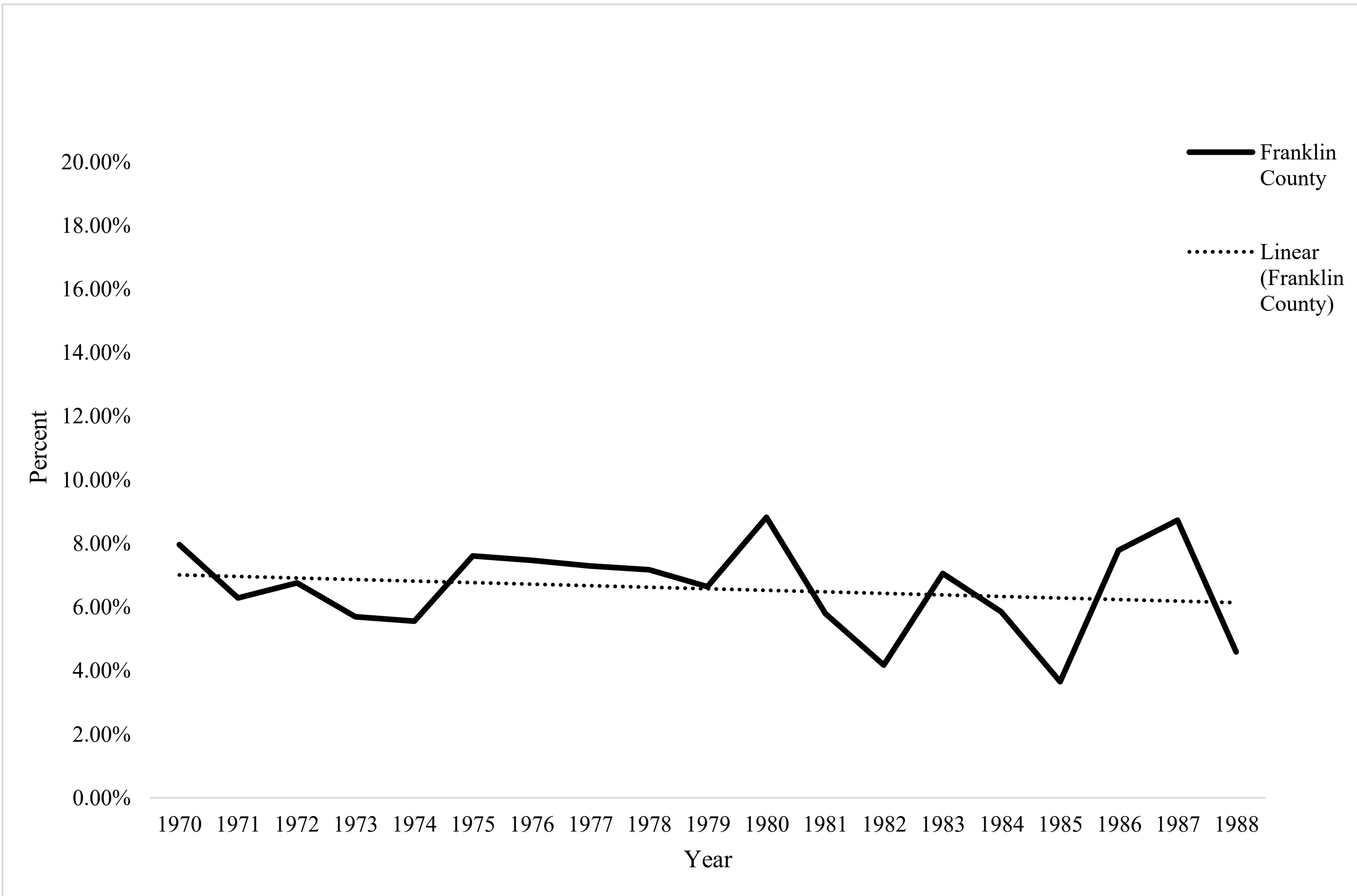

Figure 4: Percent of Babies Born with Low Birth Weight from 1970-1988 By County

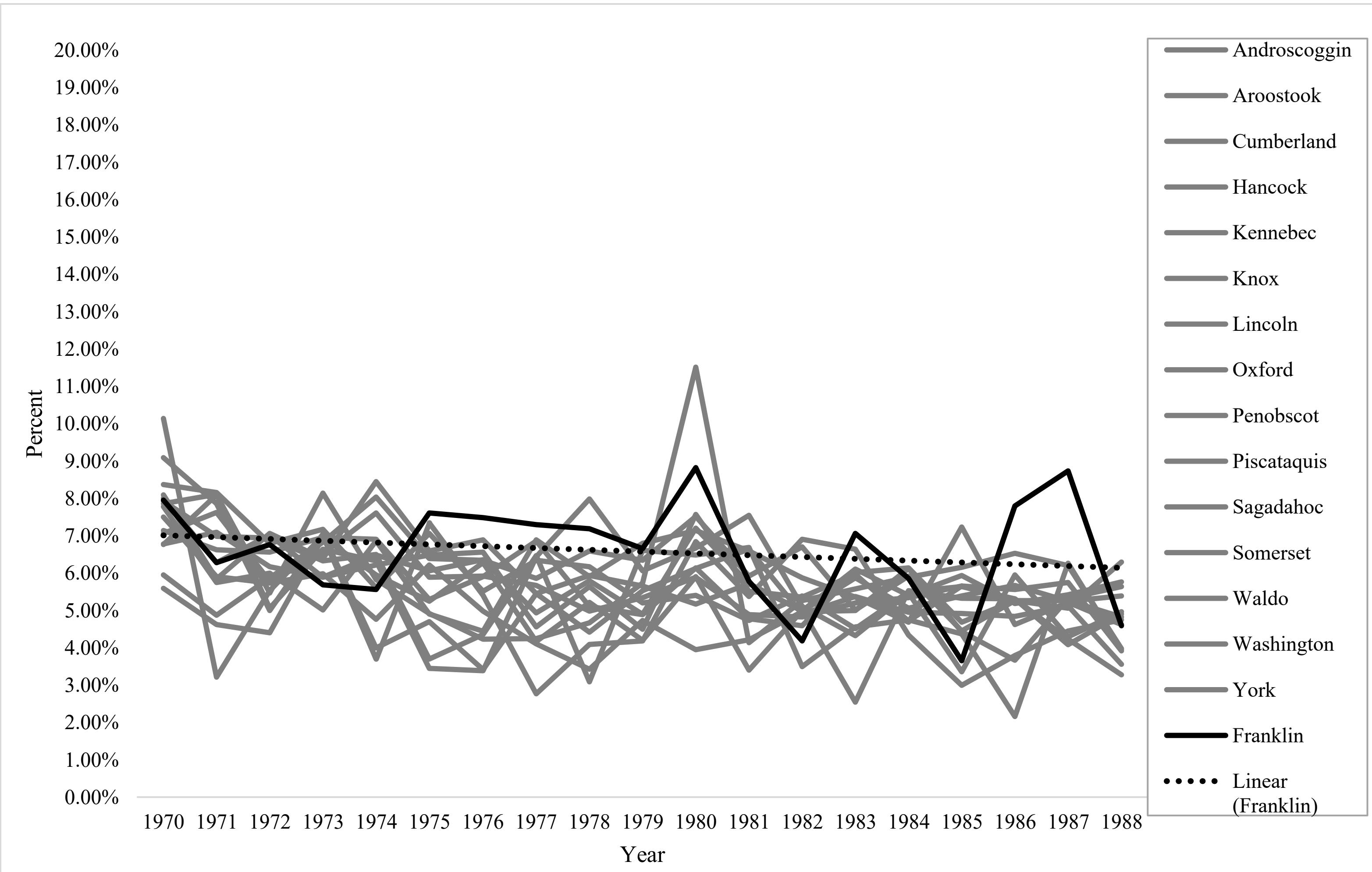

Figure 5: Percent Babies Born Preterm from 1970-1988 by County

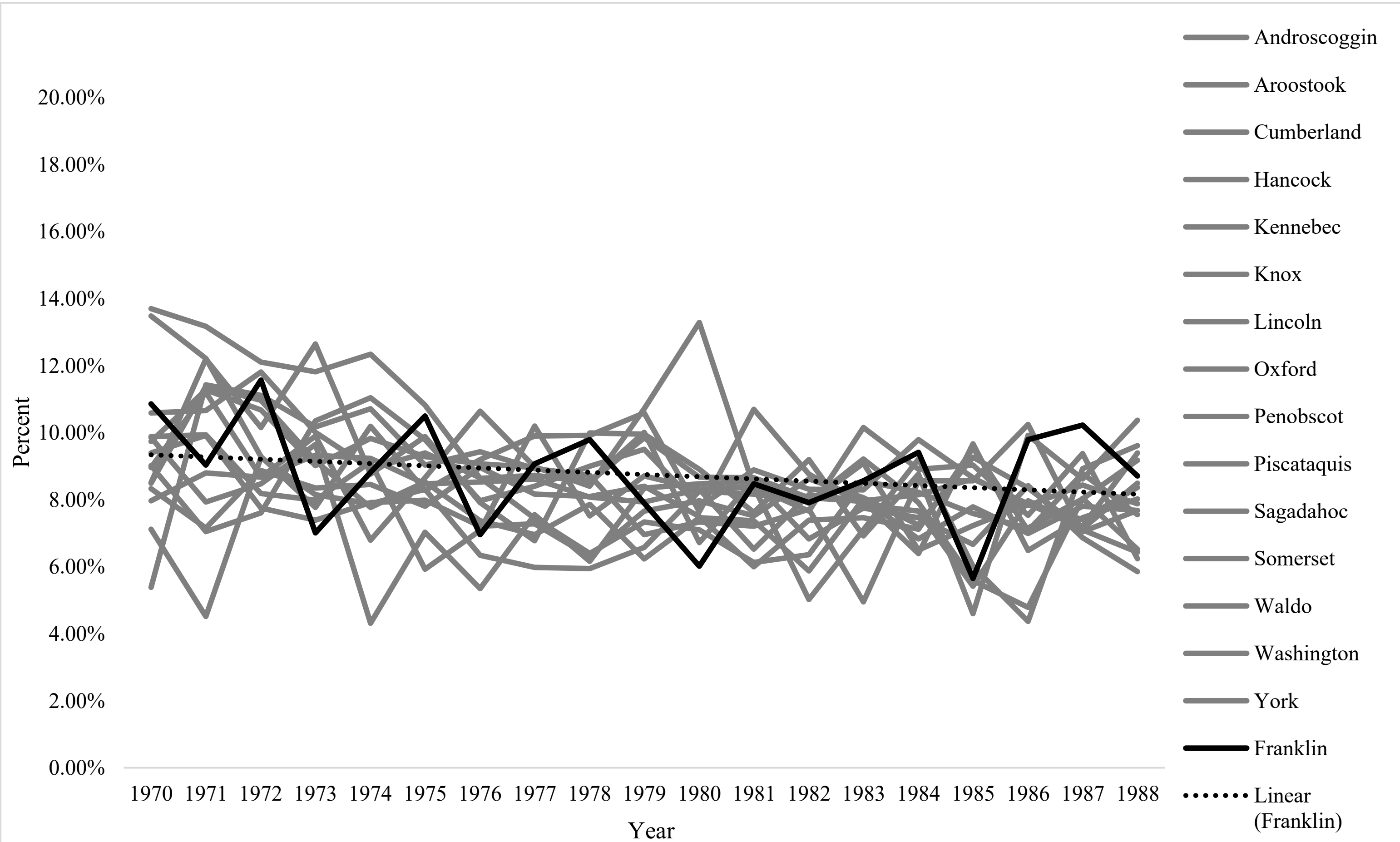

Figure 6: Household Income versus Low Birth Weight Birth Rate, Maine 1974-1978

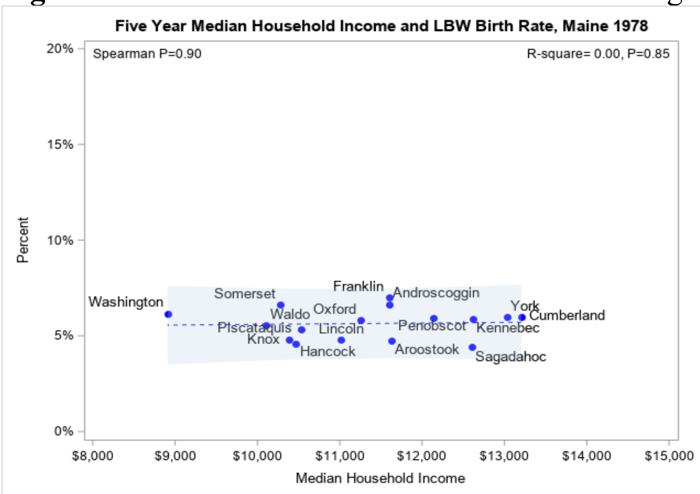

Figure 7: Household Income versus Low Birth Weight Birth Rate, Maine 1979-1983

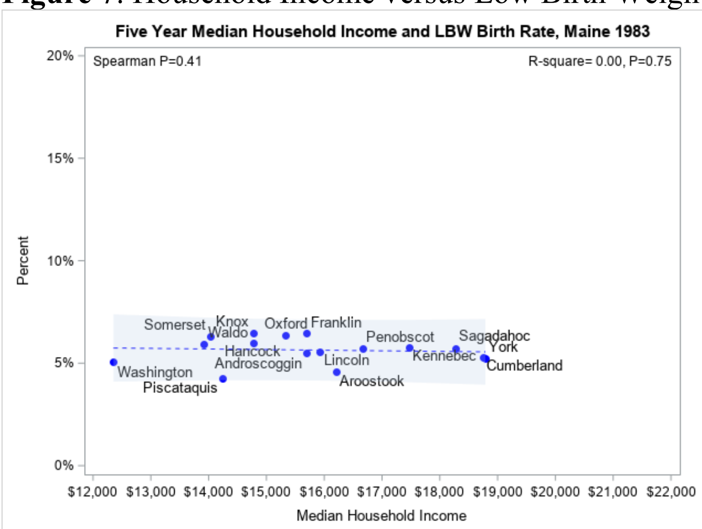

Figure 8: Household Income versus Low Birth Weight Birth Rate, Maine 1984-1988

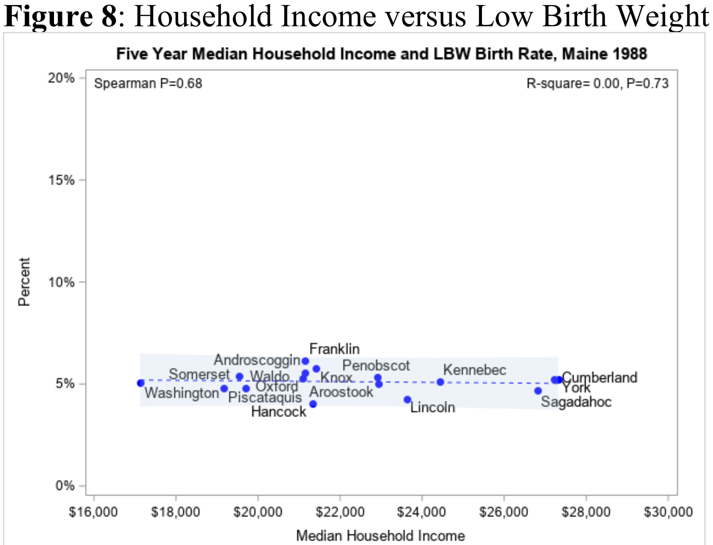

Figure 9: Household Income versus Preterm Birth Rate, Maine 1974-1978

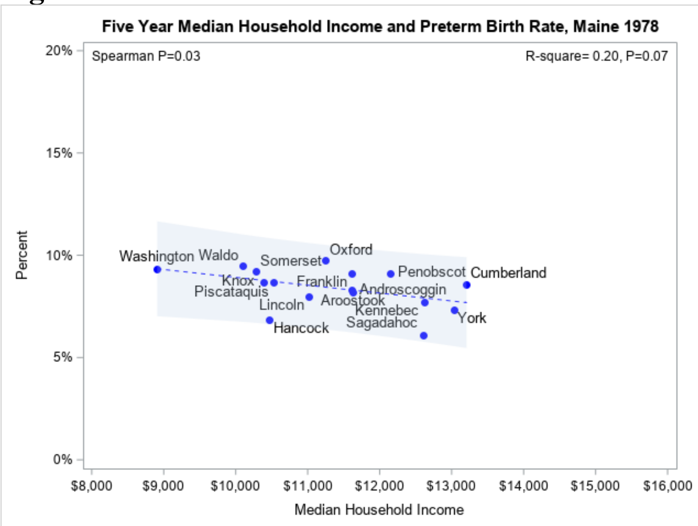

Figure 10: Household Income versus Preterm Birth Rate, Maine 1979-1983

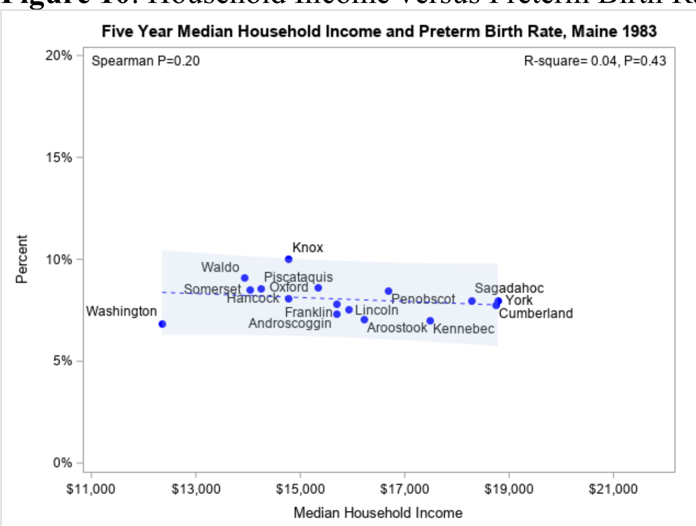

Figure 11: Household Income versus Preterm Birth Rate, Maine 1984-1988

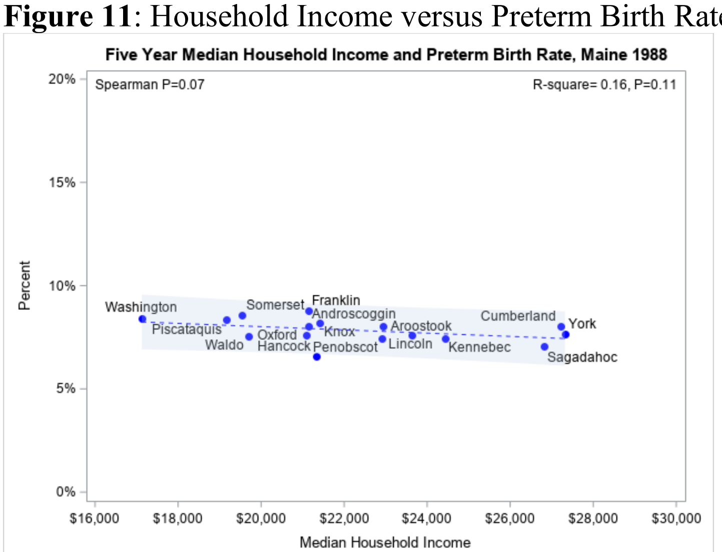

Table 1. Franklin County and All Other Maine County Preterm Births and Income Data, in 5-Year Periods, 1974-1988

	Franklin County				**All Maine Counties**	
Period	**Median Household Income, $**	**Preterm Birth Rate**	**Preterm Birth Rate vs Income T Score**	**P Value for T Score**	$\mathbf{R^2}$	**P-Value for** $\mathbf{R^2}$
1974-1978	11,606.10	0.09091	0.876	0.8026	0.2063	0.0772
1979-1983	15,686.40	0.07808	-0.305	0.3823	0.0441	0.4352
1984-1988	21,152.40	0.08810	1.678	0.9430	0.1643	0.1194

Table 2. Franklin County and All Other Maine County Low Birth Weights and Income Data, in 5-Year Periods, 1974-1988

	Franklin County				**All Maine Counties**	
Period	**Median Household Income, $**	**Low Birth Weight Rate**	**Low Birth Weight Rate vs Income T Score**	**P Value for T Score**	$\mathbf{R^2}$	**P-Value for** $\mathbf{R^2}$
1974-1978	11,606.10	0.070352	1.732	0.9481	0.0026	0.85
1979-1983	15,686.40	0.064516	1.244	0.8837	0.0069	0.75
1984-1988	21,152.40	0.061594	1.984	0.9671	0.0086	0.73

Supplemental Materials

Supplemental Table 1: Median Household Income versus Preterm Births in Maine (1970-1988)

Year	Spearman P-Value	R^2	P-Value
1970	0.86	0.05	0.39
1971	0.27	0.01	0.68
1972	0.76	0.00	0.72
1973	0.37	0.06	0.33
1974	0.23	0.14	0.15
1975	0.46	0.03	0.49
1976	0.14	0.14	0.14
1977	0.24	0.05	0.36
1978	0.04	0.19	0.09
1979	0.23	0.07	0.31
1980	0.71	0.01	0.62
1981	0.24	0.09	0.25
1982	0.22	0.07	0.31
1983	0.47	0.08	0.27
1984	0.14	0.13	0.16
1985	0.48	0.02	0.52
1986	0.34	0.05	0.37
1987	0.34	0.10	0.23
1988	0.31	0.11	0.19

Supplemental Table 2. Median Household Income versus Low Birth Weights in Maine (1970-1988)

Year	Spearman P-Value	R^2	P-Value
1970	0.99	0.00	0.73
1971	0.87	0.00	0.91
1972	0.46	0.02	0.55
1973	0.15	0.13	0.16
1974	0.48	0.02	0.58
1975	0.97	0.00	0.94
1976	0.25	0.04	0.44
1977	0.97	0.00	0.77
1978	0.18	0.06	0.35
1979	0.39	0.02	0.53
1980	0.63	0.01	0.63
1981	0.98	0.00	0.90
1982	0.01	0.14	0.15
1983	0.11	0.12	0.18
1984	0.55	0.00	0.75
1985	0.69	0.00	0.85
1986	0.28	0.03	0.49
1987	0.02	0.04	0.44
1988	0.32	0.05	0.36

Supplemental Table 3: Median Household Income versus Preterm Births in Maine (1970-1988), Sensitivity Restricted to First-Born Singleton Births

Year	Spearman P-Value	R^2	P-Value
1970	0.48	0.00	0.86
1971	0.44	0.09	0.24
1972	0.76	0.00	0.72
1973	0.81	0.00	0.89
1974	0.05	0.31	0.02
1975	0.33	0.11	0.20
1976	0.01*	0.29	0.02*
1977	0.46	0.02	0.59
1978	0.79	0.02	0.54
1979	0.87	0.02	0.56
1980	0.85	0.00	0.72
1981	0.02*	0.3	0.02*
1982	0.02*	0.23	0.05*
1983	0.96	0.00	0.71
1984	0.07	0.10	0.23
1985	0.62	0.00	0.83
1986	0.27	0.11	0.20
1987	0.01*	0.29	0.02*
1988	0.20	0.15	0.13

* P-value <0.05. Slopes (decrease in preterm birth for each $1,000 increase in median household income) for 1976, 1981, 1982, and 1987 were: : -0.0058, -0.0047, -0.0041, and -0.0035

Supplemental Table 4: Median Household Income versus Low Birth Weight Births in Maine (1970-1988), Sensitivity Analysis Restricted to First-Born Singleton Births

Year	Spearman P-Value	R^2	P-Value
1970	0.56	0.03	0.47
1971	0.37	0.01	0.66
1972	0.79	0.00	0.90
1973	0.73	0.00	0.88
1974	0.97	0.00	0.81
1975	0.68	0.06	0.34
1976	0.52	0.02	0.54
1977	0.74	0.01	0.64
1978	0.74	0.00	0.86
1979	0.21	0.03	0.51
1980	0.45	0.00	0.82
1981	0.86	0.01	0.66
1982	0.02	0.22	0.06
1983	0.05	0.16	0.11
1984	0.69	0.03	0.47
1985	0.96	0.02	0.54
1986	0.5	0.10	0.22
1987	0.96	0.01	0.70
1988	0.16	0.04	0.41

Supplemental Table 5: Median Household Income versus Preterm Births in Maine (1970-1988), Sensitivity Analysis Restricted to Non-Missing Gestational Age births

Year	Spearman P-Value	R^2	P-Value
1970	0.59	0.01	0.64
1971	0.61	0.03	0.48
1972	0.14	0.09	0.24
1973	0.15	0.16	0.11
1974	0.21	0.04	0.41
1975	0.58	0.02	0.52
1976	0.10	0.13	0.16
1977	0.24	0.16	0.12
1978	0.01	0.23	0.05
1979	0.13	0.11	0.19
1980	0.48	0.00	0.80
1981	0.47	0.02	0.54
1982	0.24	0.07	0.29
1983	0.20	0.15	0.12
1984	0.16	0.09	0.24
1985	0.82	0.00	0.71
1986	0.24	0.04	0.42
1987	0.67	0.00	0.79
1988	0.54	0.02	0.60

Supplemental Table 6: Median Household Income versus Low Birth Weight Births in Maine (1970-1988), Sensitivity Analysis Restricted to Non-Missing Gestational Age Births

Year	Spearman P-Value	R^2	P-Value
1970	0.72	0.00	0.79
1971	0.72	0.00	0.90
1972	0.74	0.00	0.93
1973	0.03	0.20	0.07
1974	0.97	0.00	0.73
1975	0.84	0.00	0.77
1976	0.37	0.03	0.51
1977	0.71	0.00	0.91
1978	0.15	0.10	0.21
1979	0.23	0.01	0.70
1980	0.24	0.06	0.35
1981	0.92	0.00	0.80
1982	0.04	0.14	0.14
1983	0.25	0.11	0.20
1984	0.82	0.00	0.84
1985	0.93	0.08	0.99
1986	0.64	0.01	0.64
1987	0.09	0.06	0.33
1988	0.61	0.04	0.4