Apr 20th, 1:00 PM - 3:00 PM

Pollution and Infant Mortality

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December 15, 2017

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Abstract: This paper will discuss the effects of exposure to pollution, in particular particulate matter, on infant mortality rates in the United States. Other variables that are considered are statewide unemployment rate, disposable income per capita, race, education level, and public official corruption. It is determined that pollution is significant to infant deaths in the U.S. However, the secondary independent variables are deemed insignificant.

I. Introduction and Literature Review

Infant mortality is a subject that has little answers as to why a life so young can die. Many researchers have found that pollution levels may be a main contributor to such tragic events. With increasing construction and gas emissions from vehicles, pollution levels have increased within the United States. The particulate matter within the tainted air may be the cause of adverse health effects and death among infants. According to the U.S. Environmental Protection Agency, particulate matter is a complex mixture of extremely small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. This is especially dangerous to infants that are exposed to such particle pollution because of an underdeveloped immune system. Several studies have been conducted studying the relationship between infant mortality and pollution levels. In this study we will be looking at the effect of pollution, income, race, education level, public corruption levels, and unemployment rate on infant mortality as well. We will find that pollution is the only independent variable that can significantly predict infant mortality rates. The ideas for the control variables can be traced back to prior research, as the control variables taken into account included race, income, and education level.

In 2001, researchers from the CDC, the National Center for Environmental Health, and the Environmental Health program a conducted a U.S.-wide study was done connecting the relationship between air pollution exposure and adverse infant health effects. The researchers mainly collected birth data of major metropolitan areas located in the Northeast from 1994-1996 using birth certificates from the Nation Center of Health Statistics. "Analysis stratified by race/ethnicity revealed that the association between carbon monoxide levels and term low birth weight was more consistent and stronger for African–American infant"(Maisonet, Bush, &

Correa, 2001). This highlights a possible relationship between pollutant levels, low birth weight, and race. Although this research does not connect directly to infant mortality, low birth weight can be dangerous for infants, which may lead to mortality. "Even a small increase in the risk for low birth weight from such levels could translate into a substantial number of affected infants with an increased risk for mortality and for developing other serious health problems, including developmental disabilities and chronic respiratory conditions" (Maisonet, Bush, & Correa, 2001). Thus, this study highlights that exposure to air pollutants may be correlated with infant mortality within the United States.

Using cross-section data within the United States, research from the Public Health Research Group studied the possibility of air pollution exposure correlating to increased risk of infant mortality from respiratory causes and sudden infant death syndrome (SIDS). Studying births across the U.S., there is a slight correlation between particulate matter (PM) levels and infant mortality from SIDS or respiratory issues. "There were differences in the magnitude and consistency of association by cause of death, with postneonatal mortality due to respiratory causes and SIDS being more consistently associated with PM levels"(Glinianaia, Rankin, Bell, etc., 2004). Although the significance does not breed a direct causation, it is shown that higher levels of particulate matter exposure in the U.S. may lead to an increase in infant mortality rates.

In 2006, researchers from Harvard School of Public Health and Brigham Young University delved deeper in studying the health effects of air pollution on infants. In particular, this study focuses on short term effects of pollution levels as infants are only exposed to the pollutant for a short duration of their life. The study highlighted that "postneonatal infant mortality for all causes, respiratory causes, and sudden infant death syndrome (SIDS) were associated with particulate air pollution" (Dockery & Pope III, 2006). This shows that even in the short term, increased pollution levels have the ability to fatally affect infants. This finding can also be extended to mortality in children, which further emphasizes the positive correlation between pollution levels and mortality in the U.S. "There is also substantial and growing evidence that air pollution is a risk factor for increased mortality in infants and young children" (Dockery & Pope III, 2006). This is mainly highlighted within the researcher's short term data, as the longer term data focused more on adverse health effects in the elderly from air pollution. That correlation also highlights how those with comprised immune systems (i.e. infants and the elderly) have an increased risk of mortality if live in an area within the U.S. that has a high pollution level.

Another study with researchers from the University of California, Emory State University, and the National Center for Health Statistics found that as the pollution levels directly correlate with infant death rates from 1999 to 2002. The researchers calculated the average concentration of pollutions such as particulate matter, ozone, sulfur dioxide over the first two months of life. This was conducted in U.S. counties containing more than 250,000 residents. It was found that "infants in the highest quartile of exposure had elevated odds of respiratory mortality, compared with infants in the lowest quartile of exposure for particulate matter" (Woodruff, Darrow, & Parker, 2008). The increased probability of infant death for those with elevated pollutant exposure levels highlights a possible relationship between the two variables. The study mainly found that most of the infant deaths were caused by respiratory issues. It should be noted, however, that race and mother's education are taken into account. "Our study cohort was demographically similar to the eligible births in the United States, though we had a slightly higher percentage of mothers with less than12 years of education and a slightly higher percentage of Hispanic and black mothers (with a complementary decrease in white mothers)"

(Woodruff, Darrow, & Parker, 2008). Taking into account these other variables, it is possible that there may be a secondary correlation between race or education level and infant mortality. This shows that other variables other than pollution may contribute to infant mortality and should be mentioned when conducting research as it may change the interpretation of the results.

In 2004, researchers from the Institute for Social and Preventative Medicine further corroborated that there is a possible correlation between air pollution levels and infant mortality. Exposure was defined as the average outdoor particulate matter levels for the first two months of life. Levels were found using a tested exposure-response function. Researchers controlled for factors such as maternal education, maternal ethnicity, and parental marital status. 25 U.S. counties were studied, and most of these included metropolitan areas. “The estimated proportion of all causes of infant mortality, SIDS (normal birth weight) and respiratory disease mortality (normal birth weight) attributable to PM above the reference level was 6%, 16%, and 24% respectively. This estimate might be a reasonable approximation of the attributable proportion across all metropolitan areas of the U.S.” (Kaiser, Romieu, Medina, etc., 2004). With almost a quarter of infant deaths from respiratory disease linked to particulate matter levels, there may be a correlation between pollution and infant mortality. Although much of the past research generally finds a slight correlation between air pollution and infant mortality, other variables in addition to this primary independent variable should be studied further.

II. Theoretical Model

The fixed effect model we will be considering is based on the equation:

Infdeath= f (pollut, inc, unemp, white, hsgrad, corrupt)

Where infdeath is the number of infant deaths per 1,000 births, pollut is the average exposure of the general public to particulate matter of 2.5 microns or less in size, inc is the disposable income per capita, unemp represents the unemployment rate, white represents the percentage of white citizens, hsgrad is the high school graduation rate, and corrup is the percentage of public official corruption.

All of the variables are annual and statewide, sectioned by each of the 50 states in the United States for years 2007-2015. As shown in the equation above, the dependent variable is infant death with independent variables of pollution exposure, disposable income per capita, unemployment rate, percentage of white population, percentage of high school graduates, and public official corruption. My hypotheses for the expected beta signs of each variable are found in Table I under the Appendix section.

This fixed effect model did have a serial correlation problem with a Durbin Watson Statistic below its lower bound. A white period coefficient variance method was then used to estimate the equation.

III. Data Description

The data for this study was mainly found through the americashealthrankings.org website, the Center for Disease Control site, the Bureau of Economic Analysis, the Bureau of Labor Statistics, higheredinfo.org, and justice.gov. The America's Health Rankings provide state-by-state data from the CDC. The CDC is a federal agency promotes health and preparedness in the U.S. with an ultimate goal of bettering public health. The BEA is an official government agency that provides macroeconomic statistics. The BLS is an agency committed to finding facts about labor in the United States and is a unit of the Department of Labor. Higheredinfo.org provides up to date information about nationwide statistics concerning statewide data. Justice.gov offers an in-depth look at crime within the U.S. and by state basis.

The study looks at state by state data from 2007 to 2015 with 450 observations per variable. A summary of the data statistics are located in the Appendix section on Table II.

Infant Death

The dependent variable, infant death, represents the number of infant deaths per 1,000 births. The highest number of infant deaths for any state on any given year was Louisiana in 2008 and Mississippi in 2009, both with 10.3 infant deaths per 1,000 births. This is inclusive of all causes of death. Both of the time periods fall around the same time as a past recession in the U.S., highlighting a possible correlation to income. The data was obtained through the America's Health Rankings website.

Pollution

In this study, pollution is measured in terms of particulate matter. The variable in this fixed effect model measures the average exposure of the general public to particulate matter of 2.5 microns or less in size (PM2.5) by state. Particulate matter is a mixture of solid particles and liquid drops in the air. The matter can be microscopic, making it easy to breathe in to the respiratory system. This is what makes PM possibly dangerous. I hypothesized that the beta for this variable would be positive as I believed that states with higher levels particle pollution, would have a higher infant mortality because PM may cause adverse health effects. The data was obtained through the America's Health Rankings website.

Disposable Income Per Capita

Disposable income per capita represents the average disposable income of an individual on a state-by-state basis. In following tables, this will be divided by 10,000 to better see the relationship this variable has with infant mortality. I hypothesized that this beta would be negative, because those with lower income may not be able to afford medical costs associated with the effects of air pollution. The data was obtained from the BEA website.

Unemployment

The unemployment rate represents the annual local unemployment rate out of state population. This does not take people below working age into account. It is found by dividing the number of unemployed citizens by the total population in a particular state. I hypothesized this variable to be positive, because if there is a higher unemployment rate, this can indicate both instability in the state as well as negatively affect people's ability to pay for medical costs associated with air pollution exposure. The data was obtained from the BLS website.

White Population

The white population variable measures the percentage of white population out of total state population. This only takes into account those that are not mixed with other races, as it includes those who are only white. I hypothesized that the percentage of a white population would be negatively correlated to air pollution levels. This is because there may be socioeconomic differences in areas with a large minority population. These areas tend to be more urban areas or lower income areas. The metropolitan areas seem to have higher levels of pollution and pollution exposure because of all the gas emissions from cars. Also, with a lower income, many may not be able to afford the proper care for an infant exposed to pollution. The data was obtained from the CDC.

High School Graduation Rate

The high school graduation rate represents the percentage of high school graduates out of total state population for every state. In the U.S., where public education is available, I expected these percentages to be close to one for each of the states. I hypothesized that the high school graduation rate would have an inverse relationship with air pollution levels and a negative beta. This can also be linked to the idea that if someone graduates high school, they will likely make a higher income than someone who did not. Generalizing this to state populations, if a larger percentage of the population did not graduate high school, they may not be able to afford the costs of treating possible diseases that can cause infant mortality. The data was obtained from hihgeredinfo.org.

Public Official Corruption

Public official corruption is measured by taking the number of public officials charged with corruption divided by the total number of public officials in each state. If corruption within the state remains low, the economy and well-being is likely steady because those running it are not corrupt. I hypothesized that the coefficient would be positive because if corruption was present, less spending may go to the health and medical facilities that can promote public health. Without this, the PM already present in the air may cause more adverse effects like death. This data was obtained from justice.gov.

IV. Results

The effect of pollution exposure on infant mortality was unsurprising as the data indicated a positive correlation between the two variables. This is not strong enough to breed causation, however. When running the fixed effect model, there was a serial correlation problem as indicated by a low Durbin Watson Statistic. To adjust for this, a White Period Coefficient Variance Method was used. This brought the significance of pollution with respect to infant death down from 1% to 10% significance. However, the data is still considered significant at a 90% confidence interval, highlighting a possible correlation between the variables. This possible positive correlation is due to the adverse health effects that result from high pollution exposure. This is highlighted in the scatterplot, Graph V, in the Appendix.

What was surprising was that none of the control variables were significant. This was interesting because most of the literary sources I researched showed a relationship between income and race. The income variable was statistically significant at 5% and 10% when most other variables were not included in the model. With the other variables being insignificant at any point, no correlation to infant mortality can be made. All of these results, including the serial correlation fixed chart, are included in the Appendix below on Table III and Table IV.

V. Conclusion

According to my findings, pollution levels have a significant effect on infant mortality rates in the United States. Stricter environmental laws on a federal level may be implemented in order to minimize the risk of adversely affecting infant health. With more funding for environmentally friendly options in terms of transportation and construction, pollution levels may be lower, as there will be less particulate matter in the air. Therefore, is may correlate to lower infant mortality rates.

Some shortcomings of the paper are the small amount of years associated with the data. I would like to study more years to highlight why pollution has increased and find longer term trends in the data. Also, using more variables that significantly affect infant mortality will help the strength of the research results.

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Appendix

Table I

	Expected Beta Sign	*Actual Significance*
Pollution	Positive	Significant
Per Capita Disposable Income	Negative	Insignificant
Unemployment Rate	Positive	Insignificant
Percentage of White Citizens	Negative	Insignificant
Percentage of High School Graduates	Negative	Insignificant
Percentage of Public Official Corruption	Positive	Insignificant

Table II

	Mean	*Median*	*Maximum*	*Minimum*	*Std. Dev.*	*Observations*
Pollution	9.79	9.7	15.3	4.6	2.34	450
Disposable Income Per Capita	37535.30	36655.50	57329.00	26456.00	5921.55	450
Unemployment Rate	0.07	0.07	0.14	0.03	0.02	450
Percentage of White Citizens	0.82	0.84	0.97	0.3	0.12	450
Percentage of High School Graduates	0.89	0.9	0.96	0.8	0.03	450
Percentage of Public Official Corruption	0.1	0.09	0.67	0	0.06	450

Table III

Variables	**Original Models (No White Period)**					
Infdeath	Model I	Model II	Model III	Model IV	Model V	Model VI
Pollut	0.08*** (3.66)	0.08*** (3.30)	0.08*** (3.30)	0.08*** (3.29)	0.08*** (3.27)	0.08*** (3.16)
Inc (10^{-5})		3.04** (1.81)	3.10* (1.79)	3.06* (1.74)	2.48 (1.36)	2.82 (1.52)
Unemp			0.375 (0.14)	0.30 (0.11)	0.15 (0.06)	0.09 (0.03)
White				-1.11 (-0.15)	-1.70 (-0.23)	-1.97 (-0.27)
Hsgrad					-2.43 (-1.16)	-2.38 (-1.14)
Corrup						0.31 (1.09)
Obs	450	450	450	450	450	450
Adj R^2	0.93	0.92	0.92	0.93	0.92	0.92
F-stat (p-value)	93.83 (0.00)	92.83 (0.00)	91.05 (0.00)	89.34 (0.00)	88.00 (0.00)	86.66 (0.00)
Serial Correlation Test (DW Stat)	1.10	1.11	1.11	1.11	1.12	1.13

Table IV

Variables	**Adjusted for Serial Correlation (With White Period)**					
Infdeath	Model I	Model II	Model III	Model IV	Model V	Model VI
Pollut	0.08** (2.05)	0.08** (2.00)	0.08** (2.01)	0.08** (2.01)	0.08* (1.95)	0.07* (1.92)
Inc(10^{-5})		3.04 (1.19)	3.10 (1.17)	3.06 (1.17)	2.48 (0.91)	2.82 (1.05)
Unemp			0.38 (0.12)	0.30 (0.10)	0.15 (0.05)	0.09 (0.03)
White				-1.11 (-0.10)	-1.70 (-0.15)	-1.97 (-0.18)
Hsgrad					-2.43 (-0.95)	-2.38 (0.91)
Corrup						0.31 (0.87)
Obs	450	450	450	450	450	450
Adj R^2	0.93	0.93	0.92	0.92	0.92	0.92
F-stat (p-value)	93.83 (0.00)	92.83 (0.00)	91.05 (0.00)	89.34 (0.00)	88.00 (0.00)	8.66 (0.00)
Serial Correlation Test (DW Stat)	1.10	1.11	1.11	1.11	1.12	1.13

Graph V