

Do Air Pollutant Emissions Lead to an Increase in
Total Personal Health Care Costs by State?

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Executive Summary

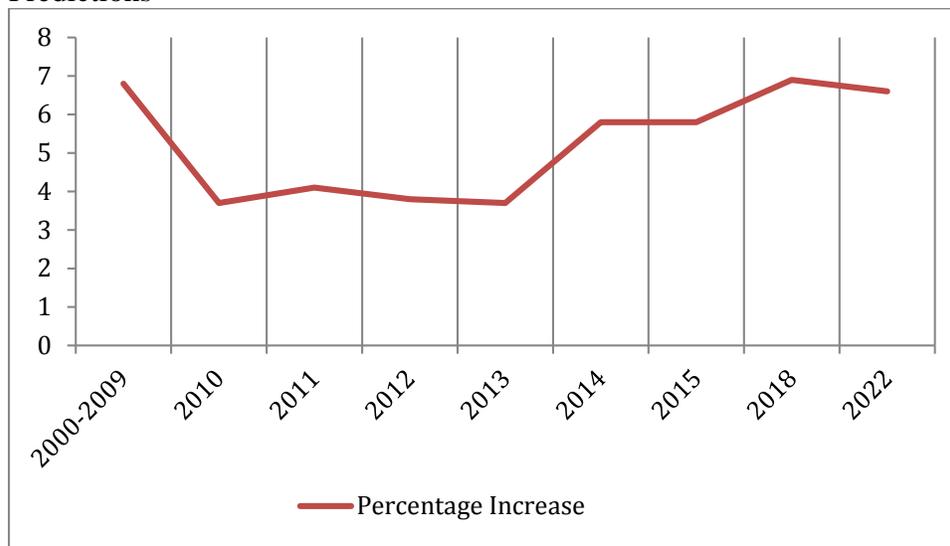
Total personal health care costs are increasing in the United States every year. Currently personal health care costs are predicted to increase at a national average rate of 6.5 percent. This is on track with the historical data. The increase has returned to the 6.0 percent mark after falling down to an increase of 3.7 percent in 2013. Recovering from the recession and the implementation of the Affordable Care Act has contributed to the steady increase back up to the average 6 percent increase per year. When looking at individual states, all averaged around the 6 to 8 percent increase per year from 2003 - 2009, which fits on trend with the national data. It is likely that the states are again up to the 6-8 percent annual increase in total personal health care expenditure.

This capstone examines the factors that affect state healthcare costs. The primary variables of interest in this study include environmental air pollutants, which could be having an effect on health care costs based on state emission levels. The EPA and other literature have cited that exposure to these air pollutants may have an adverse effect on citizen's health. If citizens have declining health, it would lead to increased health care costs. To test this possibility I run a multiple-regression of panel data with fixed effects for air pollutants and health care costs, while controlling for other explanatory variables. Findings indicate that air pollutant emissions have no effect on total personal health care costs by state.

The only statistically significant variable in the model is the proportion of obese residents in a state. The fixed effects model shows the changes in the obesity percentage in relation to the change in the health care costs. States with a higher obesity percentage spend more on healthcare. The model also includes a graph of the United States, using their Federal Information Processing Standards, which ranked states depending on how much they spend above or below the normal rate on health care, relative to their GDP. The ranking showed New England states spent above relative to GDP and southern states spent less. The ability to analyze data on a twenty to thirty year basis may have produced different results relative to the question.

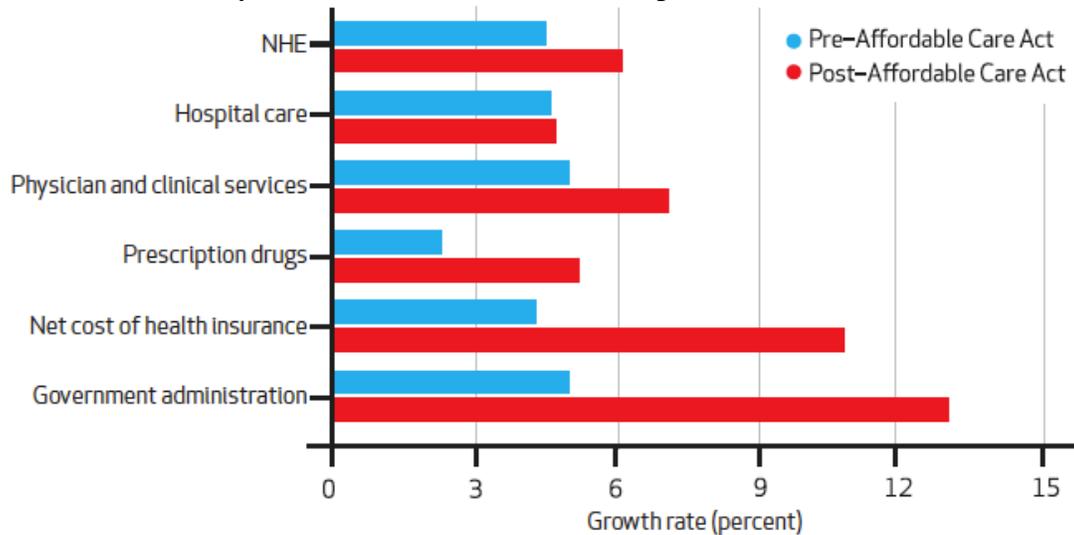
In 2015 personal health care costs for every American will increase an average of six dollars for every one hundred dollars spent per year. Analysts looking at National health expenditure data predict an annual increase of six percent for the United States as a whole. The passage of the Affordable Care Act has expanded coverage for Americans and has jump-started the rise in total personal health care costs (Cuckler et al. pg. 1820). Previous data has shown a reduction in the rate of cost increases after the recession in 2009. Figure 1 shows the average annual growth from 2000 and the predictions up to 2022. The recession and pre- implementation of the Affordable Care Act (ACA) showed slow growth in personal health care expenditure growth. However, once the economy started to recover and the ACA was implemented, personal health care costs are again predicted to the rise especially in 2014 (Figure 2). National Health Expenditure is abbreviated as NHE in Figure 2.

Figure 1
National Average Annual Personal Health Care Costs Percentage Increases and Predictions



Source : Gigi A. Cuckler, Andrea M Sisko, Sean P Keehan, Shelia D. Smith, Andrew J. Madison, John A. Poisal, Christin J. Wolfe, Joseph M. Lizonitz and Devin A. Stone. National Health Expenditure Projections, 2012-2022. Slow Growth Until Coverage Expands and Economy Improves. Health Affairs, 32 no. 10 (2013): 1820-1831.

Figure 2
2014 Growth Rates by Sector Before and After the Impact of the Affordable Care Act



Source : Gigi. A. Cuckler, Andrea M Sisko, Sean P Keehan, Shelia D. Smith, Andrew J. Madison, John A. Poisal, Christin J. Wolfe, Joseph M. Lizonitz and Devin A. Stone. National Health Expenditure Projections, 2012-2022. Slow Growth Until Coverage Expands and Economy Improves. Health Affairs, 32 no. 10 (2013): 1820-1831.

By 2015, some analysts predict personal health care costs to return to the 2000-2009 level of increasing by an average of six percent each year (Cuckler et al. pg. 1823). Although the data for 2010 till 2022 is for the national average, previous data is consistent when broken out by state. The average annual increase for total personal health care costs per state from 2000-2009 was six to eight percent per state (CMS.Gov).

What is causing the average six percent increase by year? Obvious culprits are Medicaid, Medicare, the Affordable Care Act, administration costs, drug costs and new technology (Cutler 2013). What if a silent offender in the environmental arena is also causing health care costs to increase? Even though the Clean Air Act has worked to decrease air pollutant emissions over the past twenty years, health care costs have continued to rise. Could exposure to these emissions be affecting health of the citizens

and causing their health care costs to rise? The intent of this capstone is to test whether air pollutant emissions leads to an increase in total personal health care costs by state.

Air Pollutant Background Information

The Environmental Protection Agency, in compliance with the Clean Air Act, has reported six common air pollutants found all over the United States from various industries. Nitrogen dioxide and sulfur dioxide are included in six common air pollutants and are toxic to humans. Sulfur dioxide emissions are related to energy production including coal fire power plants and coal production, and other fossil fuels, while nitrogen dioxide emissions are linked to mobile emissions (“Nitrogen Dioxide” EPA).

Both nitrogen dioxide (NO₂) and sulfur dioxide (SO₂) are linked to health problems in the short and long term. NO₂ short term and long term health effects include:

- Short Term exposures, ranging from 30 minutes to 24 hours
 - Adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma.
 - Elevated breathing, increased hospital visits for respiratory issues
- Long term exposures react with ammonia and other compounds to penetrate the lungs
 - Worsen respiratory diseases and can aggravate existing heart disease and possible premature death (“Nitrogen Dioxide” EPA).

SO₂ has similar short term and long-term health effects from exposure. These effects include:

- Short term exposures, ranging from 5 minutes to 24 hours
 - Adverse respiratory affects including bronchoconstriction and increased asthma symptoms.
 - Increased visits to hospitals for respiratory illnesses, particularly for the young and elderly.

- Long Term exposures have the ability to form sulfate particles which react with other compounds to penetrate the lungs
 - can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death (“Sulfur Dioxide” EPA).

Nevertheless, energy plants and motor vehicles are not just pumping these gases out at random. The Clean Air Act (CAA) regulates both of these air pollutants. Under the CAA, SO₂ was regulated in 2012 so that it cannot reach emission levels above 500 parts per billion to protect public welfare. NO₂ is regulated in tiers of mobile vehicles that are engineered to meet the strict standards set by the CAA. These vehicles began to be used on the roads in 2004 for light duty vehicles and the second tier of heavy duty vehicles in 2007-2010 (“Sulfur Dioxide and Nitrogen Dioxide” EPA).

Literature Review

Air pollution is not only studied in the United States but in countries around the world. A study of Dublin Ireland, in the 1990’s, after the ban of coal sales produced informational results about health and air pollution. After six years of banned coal sales:

- ambient levels of black smoke decreased 70%
- sulfur dioxide decreased by 35%
- total mortality decreased by 6%
- respiratory deaths decreased 16%
- cardiovascular deaths decreased 10% (Clancy et al. 2002).

Country studies, like Ireland, are not only informational, but include evidence that air pollutants are linked to negative health outcomes within the United States and throughout the world. Throughout the world researches have linked air pollution to:

- increased mortality
- decreased lung function

- increased respiratory illness
- decreased life expectancy in the United States (Clancy et al. 2002; Downs et al. 2007; Medley et al. 2002; Pope et al. 2009; Schindler et al. 2009).

In addition to these international studies, diminished air quality has been linked to detrimental health outcomes in several community-based studies (Woods, 2009). These studies include:

- Corburn 2007
 - Corburn's study included an analysis of New York City neighborhoods to estimate the distribution of air toxics in urban neighborhoods and their health impact assessment. (Corburn 2007)
- Mantay 2007
 - Mantay examines the spatial correspondences between asthma and air pollution in Bronx, New York City. The case study found that people living near noxious land uses were 66% more likely to be hospitalized for asthma (Mantay, 2007 pg 32.)
- Hansen, Barnett, and Pritchard 2007
 - The study focused on examining possible associations between fetal ultrasounds and ambient air pollutants during early pregnancy. The study found strong effects on reduced fetal ultrasound measures (Hansen et al. 2007).

Research about air pollution and health care is widely available, the study of air pollution directly relating to health care costs for adults has not been fully studied. Air pollution is a broad term with many different implications. The studies that have been conducted were done frequently in the 1990's and this may have been linked to the Clear

Air Act Amendments of 1990. Additionally air pollutants and health effects and costs have been studied linking specific diseases to specific populations within the United States, but not overall. Researchers are linking air pollution to increased rates of women's cardiovascular problems, childhood asthma, and mortality rates (Pope et. al, Dockerty 1995, Swartz, 1992).

Early studies on air pollution and health began in Europe in 1930, but in the United States the 1950s to the 1980s was the time period that researchers really began studying the subject and legislation regulating emissions began to get enacted/. The studies conducted in the 1960s to 1980s suggest adverse health effects connected with air pollution (Lave 1970). Further studies in 1989-1995 report adverse health effects with low levels of particulate-matter air pollution (Dockert, 1993, Pope, 1989 and 1995, Schwartz, 1993). The studies during this time period were highly controversial and prompted additional related studies, most of which confirmed the results (Pope 2004). Pope states that these studies conducted during this time period narrowed down the specific health care effects, mainly respiratory problems. Furthermore, children's research began to surface during the 1990's. Pope explains why research is narrow when it comes to human health and pollution. Researchers have found little evidence of a unique subgroup of people to study. Pope and other researchers have come to one conclusion about adults as a whole.

“Studies have shown that long-term, repeated exposure to air pollution is associated with an increased risk of death from cardiopulmonary causes in broad-based cohorts or samples of adults” (Pope ,2004, pg. 1133).

Pope's article, supported by other researches in the field (Dockery 1993 and Hoek 2003), illustrates the difficulty in finding literature that discusses the American population's health as a whole in relation to air pollution. That being said, a few studies have considered similar questions with health care cost and air pollution.

An early study on "Estimating the Health Effects of Air Pollutants" used pollution and health care estimates of both effects and costs, from the United States and other developed countries, to create a method to develop an estimate for developing countries around the world (Ostro. 1994, pgs. 2-6). Ostro provided a literature review in the study that dated back to the 1950's, in both the US and London, of researchers studying the effects of air pollutants and human health. The study picked seven air pollutants, including sulfur dioxide, and nitrogen dioxide, to study the effects on human health. Ostro then broke down each pollutant and associated the predicted health effects like asthma, morbidity, and hospital admissions associated with each effect and used time series data and produced estimates of high, central and low health changes for the population. Almost all of the mid level changes in health changes for the population were significant in affecting health care. Ostro used other industrialized countries as well as highly industrialized states to get the data for the study. Many of the same pollutants were looked at in other older studies from the 1970's listed in the article.

Substantial literature post 1994 is available about air pollutants and its effect on children in industrial. Asthma, cancer and other cardiovascular problems are now the leading causes of morbidity in children (Landrigan, 2002). If children are showing increased rates of these specific health problems, an increase in adults can arguably follow. A study published in *Children's Health Articles* in 2002, centers on estimates of

morbidity, mortality, and costs of diseases associated with air pollutants. The study used children up to five years old because that is the population most at risk for childhood asthma and they continued to use that age range throughout all of the other measures. The authors used the equation of: $\text{Costs} = \text{Disease rate} \times \text{EAF} \times \text{Population size} \times \text{Cost per case}$ (Landrigan, 2002 pg. 722). EAF in their equation represents the environmentally attributable fraction. The authors created an estimated fraction to define the fraction of diseases caused by toxins in the environment for children. The study held three panels of physicians and scientists that voted on the EAF fraction (Landrigan, 2002 pg. 722). In the study, researchers examined the rates and costs of asthma, lead poisoning, cancer and developmental disabilities.

The study not only estimated current costs associated with the diseases, but predicted economical loss for the children throughout their lifetime. Table 1 (Landrigan, 2002, pg. 726) shows health care cost estimates in total for all of the diseases studied. The total cost estimates are broken down in the study and this table does not include projected lifetime economic loss for the children. This study did not include

“the effects of diet, alcohol, tobacco, and other drugs of abuse or other drugs of abuse or other extragenetic factors such as socioeconomic status” (Landrigan, 2002, pg. 722).

Landrigan et al. did state they recognized these factors effected the overall environment, but wanted to look at the exposures that are potentially preventable with traditional approaches of public health and pollution prevention. Any study looking at adults and children would need to include the omitted variables to really present the whole picture.

Table 1: Estimated Costs (billions) of pediatric disease of environmental origin, United States, 1997(Landringan, 2002, pg. 726),

Disease	Best estimate	Low estimate	High estimate
Lead poisoning	\$43.4	\$43.4	\$43.4
Asthma	\$2.0	\$0.7	\$2.3
Cancer	\$0.3	\$0.2	\$0.7
Neurobehavioral disorders	\$9.2	\$4.6	\$18.4
Total	\$54.9	\$48.8	\$64.8

Research Design

This quantitative analysis studies the effects of air pollutant emission levels on health care costs. From the previous literature review and research on air pollutants, I hypothesize a positive relationship between air pollutant emissions and health care costs. I assume for the study that emissions affect health and that poor health affects health care costs. As a state's air pollutant emission levels increase states health care costs will also increase. The independent variables are air pollutant emissions per state, including nitrogen dioxide and sulfur dioxide. The emission level data is from the U.S. Energy Information Administration ("U.S. Energy "). The gases will be compared to states health care costs to see if any correlation between the emissions and cost can be found. All of the health problems reported by the research could contribute to the rise in healthcare costs. That being said, there remains the possibility that other factors will swamp the effects of air pollutant emissions on health care costs. The range of years in my data set was determined by the emissions data. Both emissions were reported together consistently starting in 2003 and the health care cost data is only reported until 2009, broken out into each state.

The dependent variable in this report is health care cost. The health care cost data used in this research was found on the Center for Medicaid and Medicare Services website. The data consists of total personal health care cost estimates by state or residence. Personal health care spending includes the total amount spent to treat individuals with specific medical conditions, but excludes expenditures resulting from government administration, net costs of health insurance, government public health activity, non-commercial research, and investment in structures and equipment (“Research Statistics”). The data already showed an annual average 6.5 percent growth for the whole United States over a twenty-year span. The table also broke down by year and by state. It is easy to see that all states experienced growth when it came to health care costs from the years 1990-2009. The control variables for the research question are:

- Population of the state
- Median income
- Poverty percentage per state
- State Gross Domestic Product per capita
- Health problems by state, not associated with air pollutants used in other studies (Landringan 2002).
 - Obesity (Adult Obesity Percentage)
 - Tobacco use (Adults who are Current Smokers)
 - Heavy Alcohol Use (Adult men having more than two drinks per day and adult women having more than one drink per day: Heavy Drinking Measure)

All of the health problem data is from the Behavioral Risk Factor Surveillance System Survey (BRFSS) data reported by the Center for Disease Control (“Behavioral Risk”).

I used the statistical method of multiple-regression of panel data with fixed effects for the model. The fixed effects model asks what the changes in the explanatory

variables are in relation to the change in the dependent variable. The data includes states, air pollutant emission levels, health care costs and control variables for the six years. After the initial multiple regression, I also produced a graph organized by Federal Information Processing Standards (FIPS), to identify which states are spending more (or less) on their health care given their GDP, obesity and the other control variables.

Findings

The summary statistics are shown in Tables 1-3. The states that have the highest pollution levels across the year range for SO₂ are Ohio, Pennsylvania, and Indiana. Emissions levels for NO₂ were highest among Ohio, Texas and Florida. Mississippi had the highest poverty and obesity rates across the range. California had the highest total personal health care costs and Kentucky had the highest percentage of smokers for all of the years in the data set. Washington, DC, Vermont, and Rhode Island were the lowest in SO₂ and NO₂ levels. Wyoming had the lowest health care costs. Utah had the least number of individuals smoking, and Colorado was the state with the fewest people who were obese.

The results are presented in Table 4 and suggest that air pollutants have no significant effect on health care costs per state. The findings indicate that obesity is the only factor with a significant effect on health care costs. The air pollutant emission levels have very low t values of <1 and the obesity rate has a t value of 3.12. A t value of 2 or -2 is the measure of the 95% confidence interval. States that have a higher obesity percentage have higher personal health care cost. While the results for air pollutants is initially surprising, the effects of air pollutants may take years, if not decades to emerge.

The graph (Figure 3) showing the states spending relative to their GDP proved to be more interesting than the regression model. The model did not rank the states just by what they spent, but rather what they spent above or below what was predicted from the explanatory variable. From Figure 3 it is clear that the New England states, District of Columbia, Alaska and Oregon spend the most. Southern states are mostly all at the bottom, spending less. Mississippi is ranked last among the 51 FIPS areas. Mississippi also had some of the highest obesity rates for the six years in the model, but still spent less given their GDP.

Table 1 Summary Statistics

<i>Nitrogen Dioxide</i>		<i>Sulfur Dioxide</i>		<i>Health Care Costs</i>	
Mean	76.3	Mean	174.6	Mean	35299.4
Median	64.0	Median	82.0	Median	23636.0
Range	725.0	Range	1141.0	Range	227559.0
Minimum	0.0	Minimum	0.0	Minimum	2531.0
Maximum	725.0	Maximum	1141.0	Maximum	230090.0

Table 2 Summary Statistics

<i>Median Income</i>		<i>Population</i>		<i>Poverty</i>	
Mean	47646.3	Mean	5851278.6	Mean	12.7
Median	46778.0	Median	4182742.0	Median	12.3
Range	36057.0	Range	36457776.0	Range	17.5
Minimum	32002.0	Minimum	503453.0	Minimum	5.6
Maximum	68059.0	Maximum	36961229.0	Maximum	23.1

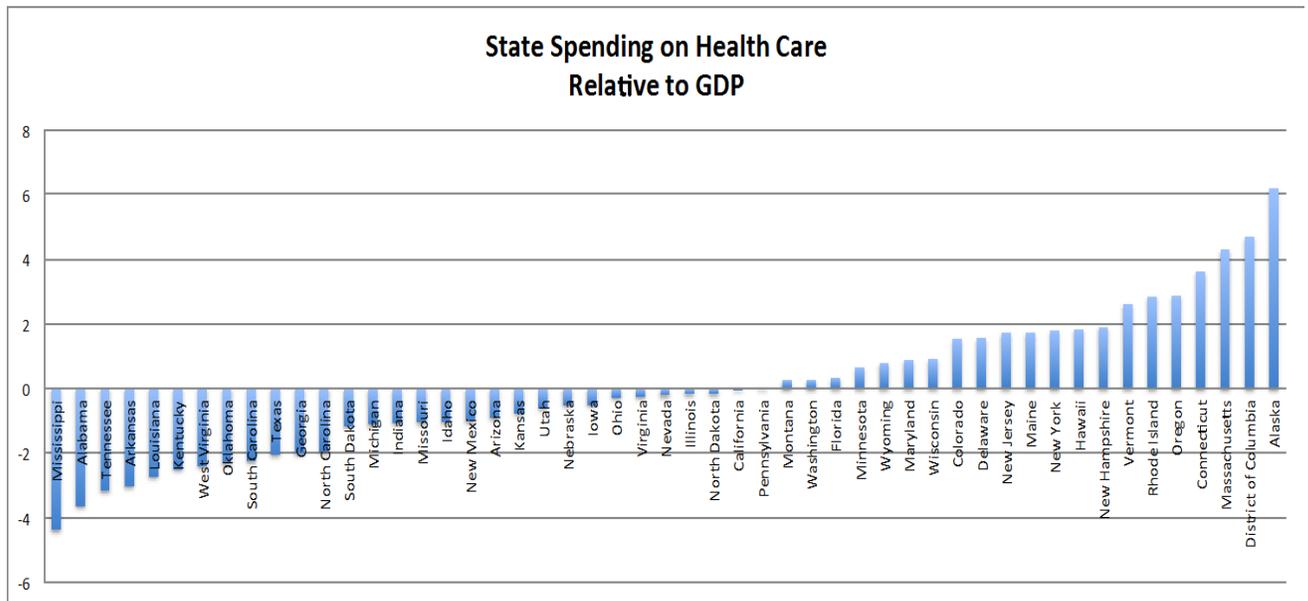
Table 3 Summary Statistics

<i>GDP</i>		<i>Adult Smokers</i>		<i>Obesity %</i>		<i>Alcohol Consumption %</i>	
Mean	283400.7	Mean	20.4	Mean	25.1	Mean	5.1
Median	170951.5	Median	20.2	Median	25.1	Median	5.1
Range	1968802.0	Range	21.5	Range	19.4	Range	6.7
Minimum	24559.0	Minimum	9.3	Minimum	16.0	Minimum	1.9
Maximum	1993361.0	Maximum	30.8	Maximum	35.4	Maximum	8.6

Table 4 Regression Statistics

Health Care Cost Per Capita	Coef.	t	P> t
GDP Per Capita	-.01	-1.37	0.17
NO2 (Thousands)	-.01	-0.01	0.99
SO2 (Thousands)	-.50	-0.33	0.73
Median Income (Thousands)	-.25	-0.01	0.99
Poverty	.11	1.05	0.29
% Adult Smokers	.03	0.30	0.76
Obesity %	.31	3.12	0.002
Heavy Alcohol user %	-.18	-0.95	0.34

Figure 3
State Spending on Healthcare Above or Below Predicted by GDP



Limitations

The limitations first deal with the data. The personal total healthcare cost data is not published from 2010 to 2014 from the Center for Medicaid and Medicare Services, Center for Disease Control, or the Kaiser Family Foundation. Having more years to compare to the emissions data may have yielded a different result. However, this is a double-edged sword. Personal healthcare costs data dates back to the 1980s and is readily available. When going further back in time, the emissions data is nonexistent. The U.S. Energy Information Administration only has data reported from 1996 and even that data is intermittent within a given year and some years are skipped. The Energy Information Administration only reports to 2011, all other emission data is still being compiled. The EPA reports that both air pollutant levels are on the decline because of the Clean Air Act and its amendments in 1990. According to the EPA most vehicles affected in the

reduction of NO₂ emissions were not implemented until 2007-2010 ("Nitrogen Dioxide"). Being able to access the data from previous years before the regulations took affect along with the ability to compare the data for over thirty years could have yielded a different result.

The second limitation is associated with the BRFSS Survey; the n for each of the health problems is not the same throughout the states. The survey is a random telephone sampling including landlines and cell phones, which collects 400,000 responses per year. The model dealt with state level data where the BRFSS Survey dealt with individual level data, reported for the state. The CDC used individual level data to make assumptions about the state.

Conclusions

This research examines the possible link between air pollutant emissions and health care costs per state in the United States. Past literature suggests that air pollutants do have an effect on citizen's health. Current research in the United States study people on a small-scale level like cities or counties not states. They have identified costs of the air pollutants associated with health but no one has directly studied the effects of pollution solely on health care costs. Pollution and costs may not be studied because the health effects air pollutants cause may not be a high cost item like obesity. In addition this area may not be studied because air pollutants are not the same state to state. Only certain states and certain areas within those states are subject to specific air pollutants. The respiratory effects linked to air pollutants may not be as prevalent within states. Studying specific states with high air pollutant levels may show pockets of adverse health effects with increased health costs.

However, this study did not find any evidence that air pollutants matter for personal health care costs by state. The only variable within the fixed effects model that demonstrates significance is the change in obesity in relation to the change in personal total health care costs. In the literature, researchers like Pope were using data sets with at least twenty years of data to study the health effects. Short time spans may not show the full effects. If more data was available in both air pollutant emission levels and personal health care costs the results may have supported the hypothesis.

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