

# Association of Suicide Rates and Coal-Fired Electricity Plants by County in North Carolina

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## ÖZET:

Kuzey Karolina'daki bir ilde intihar oranlarının kömür yakıtlı elektrik üretim tesisi ile ilişkisi

İntihar, ruh sağlığı ile ilgili durumlarla yakından ilişkili olduğu gibi, muhtemelen duygudurum bozukluklarını etkileyen yaşam kalitesi etkenleri nedeniyle çevre kirliliği ile de ilişkilidir. Bu ekolojik çalışmada, Kuzey Karolina'daki bir ildeki kömür yakıtlı bir elektrik üretim tesisi varlığının, il intihar oranlarına etkisi incelendi. Amerika Birleşik Devletleri (ABD) 2000 nüfus sayımından, Kuzey Karolina Eyalet Merkezi Sağlık İstatistiklerinin 2001-2005 ölüm oranlarından ve Çevre Koruma Acentasından alınan veriler, çoklu değişkenli doğrusal regresyon analizi ile değerlendirildi. Bu çalışma sırasında Kuzey Karolina'da 20 adet kömürlü tesis bulunmaktaydı. Kuzey Karolina nüfusunun sadece yaklaşık olarak üçte biri kentsel alanlarda yaşıyordu. Nüfusun %74'ü beyazdı ve her bir ilin ortalama nüfusu 48,000 idi. Nüfusun yaklaşık olarak %13'ü fakirlik sınırında veya fakirlik sınırının daha altındaydı. İllerin ortanca aile gelirleri yaklaşık olarak 34,000\$ idi. Eyalet bazında, Kuzey Karolina intihar oranları (12.4/100,000 nüfus) ABD nüfusuyla (10.8/100,000) karşılaştırıldığında daha yüksekti. Beyaz ırk yüzdesi, eyalet nüfusunun yaş ortancası ve her bir il başına düşen tesis sayısı doğrusal regresyon modelinin %25.8'ini açıklıyordu. Kömürlü tesis varlığı için yapılan doğrusal regresyon modeli, bir ilde fazladan bir kömürlü tesisin, her 100,000 nüfus için fazladan 1.96 intihara neden olacağını gösterdi. Kömürlü tesis varlığı, artmış nikel, civa, krom, kadmiyum, berilyum ve arsenik seviyeleri ile ilişkiliydi. Bu çalışma, kömür yakıtlı bir elektrik üretim tesisi varlığının nüfus düzeyinde intihar oranları ile ilişkili olduğunu gösteren ilk çalışmadır. İntihar çevre kirliliği ile ilişkili olabileceği için, bu çalışma, sadece hava kirlleticilerinin değil kömür yakıtlı elektrik enerjisi üretim tesislerinin emisyonlarının da düzenlenmesi ile ilgili bilgilendirmeye yardımcı olabilir.

**Anahtar sözcükler:** hava kirliliği, intihar, kömür yakıtlı bir elektrik üretim tesisi, kuzey Karolina

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## ABSTRACT:

Association of suicide rates and coal-fired electricity plants by county in north Carolina

Suicide, strongly associated with psychiatric conditions, also correlates with environmental pollution, likely due to quality of life factors which impact mood disorders. This ecological study evaluated the effect of the presence of a coal-fired electricity plant in a county on county suicide rates in North Carolina. Data from the 2000 US Census, 2001-2005 mortality rates from the North Carolina State Center for Health Statistics and the US Environmental Protection Agency were used in multivariable linear regression. Twenty coal plants existed in North Carolina during this study's period. Only about one third of the population of North Carolina lived in urban areas. Seventy four percent of the population was white, and the mean population per county was nearly 48,000. About 13% of the population lived at or below the poverty level. The median household income of counties was approximately \$34,000. County-level suicide rates were higher in North Carolina (12.4/100,000 population) compared to the US population (10.8/100,000). The linear regression model indicated that percent white race, median age of county population and number of coal plants per county explained 25.8% of the variance of county suicide rates. For coal plants, the linear regression model suggests that for each additional coal plant in a given county, there would be an additional 1.96 suicide per 100,000 population. The presence of a coal plant correlated with airborne levels of nickel, mercury, lead, chromium, cadmium, beryllium and arsenic. This is the first study to show that the existence of coal electricity plants is related to population-level suicide rates. Because suicide might be associated with environmental pollution, this study may help inform regulations not only of air pollutants, but also of coal electrical power plant emissions.

**Key words:** air pollution, suicide, coal-fired electricity plants, north Carolina

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## BACKGROUND

Suicide is a tragedy associated with certain risk factors. Nationally between the years 2000-2005, there were 10.8 completed suicides per 100,000 population (1). In addition, whites, males and the elderly (particularly older white men) are at greatest risk for suicide (1-3). In fact, in the United States in 2004, the suicide rate for men was four times higher than that of women (3). Suicide is strongly associated with psychiatric illnesses, and over 90% of people who commit suicide have a psychiatric condition (1).

The most common diagnoses among patients who commit suicide include depression, alcoholism, bipolar disorder and schizophrenia (4). Suicide is also common among people suffering from anxiety, post traumatic stress disorder and panic disorder (4,5). Other factors are also involved in suicide. For example, access to a fire arm (6); living alone (7); and unemployment and lower socioeconomic status (8) all contribute to a population's suicide rate.

One factor—environmental pollution—is not commonly thought of as relating to suicide. Nevertheless, research has shown that it is (4,9,10). Reasons for an

**Table 1: County level characteristics of North Carolina's 100 Counties (from 2000 Census)**

Mean County Characteristics	Mean Value
Population	47,879
Percent of population that is white	74.1
Median Age (years)	37.2
Percent of population at or below poverty	12.9
Percent of population residing in urban areas	34.1
Percent population with less than high school education	11.4
Median income (dollars)	34,013
Suicide rate per 100,000 population	12.4

**Table 2: Linear regression analysis for county-level correlates (independent variables) of suicide (dependent variable)**

County-level Correlates	B	Standard Error	p value
White race	0.103	0.028	< 0.001
Median age	0.338	0.134	0.013
Increasing coal plants in county	1.962	0.821	0.019

association between environmental pollution and suicide have been hypothesized to include worsened asthma or cardiac disease which decrease quality of life (4,9,10); abnormal cognition, neurological development or degeneration (10); and lower overall life satisfaction (11).

This study sets out to evaluate correlates of suicide at the county level in North Carolina. The population-level analysis (an ecological analysis) of any health outcome, such as suicide, sometimes uncovers interesting findings that would not be visible looking only at individuals in that population (12). To the author's knowledge, such an analysis has not been carried out in North Carolina. It is hypothesized that suicide is related to having a coal-fired plant in a county, acting as a substitute measure of air pollution.

## METHODS

This study was carried out using an existing database from Wake Forest School of Medicine, Department of Family Medicine. It was constructed using publically available data from the 2000 United States Census, (13) the Environmental Protection Agency (14) and the North Carolina State Center of Health Statistics (15). The database contains county-level items including population, percent urban population, median income, percent of population with a high school education, median age (from 2000 census) (13); as well as leading causes of death by county (years 2001-2005 combined as reported by the NC State Center for Health Statistics) (14). EPA data included the top air contaminants which this agency regulates. EPA data from year 1999 was used to ensure that exposure to air

pollution occurred before suicides (15).

A linear regression model was constructed using these variables as correlates or predictors (independent variables) of suicide death rates (the dependent variable). County-level variables included in the model were as follows: total population, median age, percent white, percent living at or below the poverty level, percent population living in urban areas, percent population with less than a high school education, number of coal-fired electrical plants per county, and heavy metal environmental contaminants (arsenic, beryllium, cadmium, nickel, mercury and lead). Statistical analysis was carried out using the Statistical Program for the Social Sciences version 19. Statistical significance was set at a p value <0.05.

## RESULTS

The mean suicide rate for North Carolina in 2000-2005 was 12.4/100,000 population. Table 1 displays the mean county-level characteristics based on the 2000 census. The average county population was 47,879 with a median age of 37.2 and with an average of 74.1% white residents. Nearly 13% of the population lived at or below the poverty level. Thirty-four percent of NC residents lived in urban areas and a little over 11% had not finished high school. Twenty counties had at least one coal-fired power plant—sixteen had one plant; three had 2 plants (Gaston County, Halifax County, and Robeson County); and one had 3 plants (Person County)

The linear regression model which included percent white race, median age, and number of coal plants per county

explained 25.8% of the variance of county suicide rates (Table 2). All three variables were positively correlated with increased suicide rates. This means that almost 26% of a county's suicide rate can be attributed to these three factors.

The presence of a coal-fired electrical plant in a county correlated (Pearson correlation coefficient) with the county airborne concentrations of the following heavy metals at  $p < 0.01$ : nickel (0.36); mercury (0.34); lead (0.30); chromium (0.32); cadmium (0.30); beryllium (0.37); and arsenic (0.36). However, suicide rates did not correlate with individual heavy metal concentrations.

## DISCUSSION AND CONCLUSIONS

County-level suicide rates are higher in North Carolina (12.4/100,000 population) compared to the US population (10.8/100,000) (1-3). North Carolina county-level suicide rates correlated with white race and increased median county age, reflecting national data (1-3). Curiously, poverty and education did not correlate with county level suicide rates, which is in contrast to other research (8). Also, these results did not find an association between suicide and rural residence which other studies have found (8).

This is the first study the author is aware of correlating the existence of coal plants in a county with county-level suicide rates. Although suicide has been associated with

environmental factors such as pollution (9,10), the association with coal electrical plants has not been described. Since suicide correlates with air pollution, and since coal plants emit air pollutants, it is possible that the finding in this study is valid. However, although heavy metal air contaminants are correlated with coal plants in this data set, these correlations were small (all Pearson correlation coefficients  $\leq 0.37$ ). It is unclear why the environmental contaminants themselves did not correlate with suicide rates in this study. One reason might be that there are multiple sources of heavy metals in the air, not simply from coal plants, which would also explain why the correlation coefficients were small.

This study is subject to a number of limitations. First, this study looked only at county-level characteristics, and not those of individuals. In addition, there are multiple factors which contribute to suicide (8). This study could not control for these factors in individual residents, and did not have all possible socioeconomic data for each county. Still, this study raises the interesting question of whether suicide in a given population is related to the presence or absence of coal plants. If this is true, further research is needed to understand what factors related to coal burning actually account for this relationship. Also if this is true, tighter regulation of coal power plant emissions might cut down on county suicide rates in North Carolina.

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