Lignite Deposits and Kidney and Renal Pelvic Cancers in Texas 1980–1998

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Bio:

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Abstract:

Kidney and renal pelvic cancers are a major cause of morbidity and mortality in Texas.

According to the National Cancer Institute's (2007) state cancer profiles, Texas ranked second nationwide in the incidence of kidney and renal pelvic cancers in 2003. Previous studies in the Balkan Peninsula revealed a link between high rates of kidney and renal pelvic cancer and the presence of Pliocene lignite deposits. This study investigates the relationship between the presence of Pliocene lignite deposits and age-adjusted mortality rates for kidney and renal pelvic cancers, defined as ICD189.0 and ICD189.1, respectively, in Texas from 1980 to 1998. Age-adjusted mortality rates for kidney and renal pelvic cancers are above average in Texas counties that contain lignite deposits. This study also probes the role of such factors as race, gender, and socioeconomic status on mortality rates for these cancers.

Introduction

In the United States, mortality rates from kidney and renal pelvic cancers have experienced the second highest rate of increase of any cancer from 2000 to 2004. Texas had the seventh highest age-adjusted mortality rate and the third highest incidence rate for cancers of the kidney and renal pelvis in the United States between the years 2000 and 2004. Not only is the mortality rate from kidney and renal pelvic cancers in Texas above the national average, it is also increasing at the fourth highest rate in the country. For cancers that exhibit these high mortality rates, as well as increasing rates of incidence and mortality, it is imperative to understand the geography of the mortality and the incidence to identify the regions with a greater risk of developing these cancers.

This paper explores the geography of kidney and renal pelvic cancers in Texas by examining mortality data at the county level. Several variables will be used to explain the mortality rates, including race, gender, socioeconomic status, and environmental elements. The discussion uses the human ecology conceptual framework, which suggests humans can interact with their environment in ways that can produce disease. An illustrative example of such an interaction is an event in which the people in villages at the foot of a volcano fall ill due to the release of toxic gases during an eruption.

Methodology and Data Sources

Kidney and renal pelvic cancers will be defined in this study by ICD-9 codes 189.0 and 189.1. Mortality statistics from 1980 to 1998 were obtained from the Texas Department of Health's Bureau of Vital Statistics. Mortality rates have been age-adjusted to compensate for differences in age distribution between counties. Population data was obtained from the United

States Census for 2000. Socioeconomic status is defined here by median household income by county and by percentage of population with at least a ninth-grade education. Information on the location of coal deposits in Texas was obtained from the U.S. Geologic Survey.

Factors Associated with Cancers of the Kidneys and Renal Pelvis

Kidney and renal pelvic cancers are cancers that affect the renal pelvis and proximal tubules of the kidneys that are responsible for separating waste from the blood (Orem & Tatu, 2001). Mortality from these cancers usually results from uremia, which is the buildup of toxic compounds in the bloodstream that causes major organ failure. People who are diagnosed with cancers of the kidney and renal pelvis have two main options for treatment. They can either undergo a regular dialysis treatment or receive a kidney transplant. Without treatment, kidney and renal pelvic cancers will result in death.

There are many possible causes of kidney and renal pelvic cancer. The human ecology model suggests that disease is the result of the interaction of three main variables: genetics, environment, and human behavior. Genetics refers to the idea that genes limit our possible responses to physical insults. A person whose family has a history of kidney and renal pelvic cancer is more at risk of developing these cancers than those who do not. Human behaviors can alter risk levels for certain diseases if a person participates in an activity that is known to be associated with either increased or decreased risk of disease. Some factors that are associated with kidney and renal pelvic cancers are cigarette smoking and ingestion of, or exposure to, toxic substances (Kreiger, Marrett, Dodds, & Hilditch, 1993). Environmental variables that affect disease are things such as air quality, water quality, proximity to urban areas, and mineral

content of soils in the area. Environmental insults are perhaps the greatest concern because they will affect all people in a region, regardless of their social or behavioral choices.

Many residents in rural Texas rely on well water to meet their water needs. Some areas of northeast Texas contain Pliocene lignite (low rank coal) deposits that are in close proximity to freshwater aquifers. Lignite deposits naturally contain several nephrotoxic compounds such as the polycyclic aromatic hydrocarbons (PAH), benzopyrene, benzanthracene, and benzo(a)fluoranthene (Tatu, Orem, Finkelman, & Feder, 1998). The PAHs are present in higher concentrations in Pliocene lignite because this lignite is relatively young and contains many of the organic compounds that were originally present in their plant precursors. Groundwater can leach the toxic organic compounds from the lignite deposits and transport them to areas where groundwater is drawn for human use. When people drink or cook with contaminated water over a long period of time, the toxic organic compounds can accumulate in the kidney tissue and result in damage. The proposed connection between Pliocene lignite deposits, drinking water derived from areas proximal to the deposits, and mortality from kidney and renal pelvic cancers in Texas results from the research in Eastern Europe concerning Balkan endemic nephropathy (BEN) and other urinary tract cancers like renal pelvic cancer (Tatu et al., 1998). BEN occurs in highly restricted geographic areas that are proximal to lignite deposits, have stable rural populations, and use untreated water sources (Tanchev, Evstatiev, Dorossiev, Penchava, & Zvetkov, 1956). Areas of northeastern Texas also exhibit these characteristics, which put the inhabitants of these areas at risk for diseases associated with BEN, like kidney and renal pelvic cancer.

In Texas, 60% of the usable water is derived from groundwater (Texas Water Institute). Groundwater is most often harvested from aquifers. An aquifer is defined as a geologic unit of permeable material that is capable of providing usable quantities of water. If an aquifer becomes

contaminated, a large number of people can be affected. Health risks associated with water consumption can be either natural or anthropogenic contamination of source waters. The contamination of groundwater is dependent on the materials in the earth that host the aquifer (Committee on Research Priorities, 2007). Aquifers that are proximal to lignite deposits are more susceptible to contamination from PAHs and other toxic organic compounds. Susceptibility to contamination depends on soil type, depth of groundwater, vadose zone physical properties (how well subsurface fluids travel through a given region), recharge (precipitation and infiltration), subsurface attenuation processes, and proximity to lignite deposits (Committee on Research Priorities,, 2007). For example, an aquifer at comparable depth to a nearby lignite deposit in an area of sandy soil is more likely to suffer contamination than an aquifer that is deep in the earth under clay-like soil, far from any known lignite deposits.

Polycyclic aromatic hydrocarbons are not the only compounds contained in Pliocene lignite deposits that are associated with increased risk for certain diseases. Arsenic, mercury, lead, and selenium are all elements that are associated with coal. Long-term chronic arsenic exposure has been linked to a range of health problems, including cancers of the skin, lungs, bladder, and kidneys (Committee on Research Priorities,, 2007). Mercury is a potent neurotoxin that has been associated with developmental problems in the fetus, as well as diseases of the liver and kidneys of children and adults. Mercury can be acquired by skin contact, inhalation, or ingestion; however, the most likely source of human exposure to mercury is consumption of fish that live in mercury-rich waters (Committee on Research Priorities, 2007). Selenium is a trace element, which means that in a given sample of earth, the average concentration of selenium will be less than 100 micrograms per gram. High levels of selenium in water used for irrigation have

been linked to birth defects and embryonic abnormalities in birds (Committee on Research Priorities, 2007).

Hypotheses

1. There is a significant correlation between race/ethnicity and mortality from kidney and renal pelvic cancers.
2. More men suffer mortality from kidney and renal pelvic cancers than women.
3. Socioeconomic status influences mortality rates from kidney and renal pelvic cancers.
4. Counties that contain lignite deposits have high mortality rates for kidney and renal pelvic cancers.

The state average for age-adjusted mortality rates for kidney and renal pelvic cancers occurring in both genders in Texas is 4.268 deaths per 100,000. Rates are above the average in 117 out of 254 counties. The counties experiencing above-average rates are dispersed throughout the state, with the exception of the Texas-Mexico border, where only 4 of the 13 border counties exhibit above-average rates. Throughout the western, northern, and Panhandle regions, the distribution of high mortality rates shows no evident pattern. Twelve of the 16 counties that border the Gulf of Mexico have above-average mortality rates. Extending from south-central Texas to the northeast, there are two lines of adjacent counties with above-average mortality rates. The southernmost line extends all the way to Louisiana and shares borders with counties that have above-average rates of kidney and renal pelvic cancers. Figure 1 shows a map with the locations of the counties with above-average mortality rates and lignite deposits in Texas. The northern edge of the lignite deposits is completely covered with counties having high mortality

rates. The counties that border the lower edge of the lignite deposits also seem to experience high mortality rates. Out of the 117 counties in Texas that have above-average mortality rates, 49 contain some amount of lignite deposits. The aquifers that are located near the lignite deposits are mostly semi-consolidated sand aquifers, which have a higher risk of becoming contaminated by the leaching of compounds from surrounding areas.

For cancers of the kidneys that occur in both genders, the state average is 4.201 deaths per 100,000. About half of the counties in Texas experience above-average rates (refer to Map 2 in Figure 2). There is a cluster of high density counties with high mortality rates in the region of the state that begins in the south-central area and extends northeast to Louisiana. The north, west, and Panhandle regions also contain counties with high mortality rates, but there are no visible trends.

Map 3 in Figure 3 shows the spatial distribution of age-adjusted mortality rates for cancers of the renal pelvis. The state average is 0.067 deaths per 100,000 for these cancers. Only 51 of Texas' 254 counties experience above-average rates. The high mortality rates are almost totally confined to the eastern half of the state, with only four counties in the western half exhibiting high rates. The majority of counties with high mortality rates are located on the north and south edges of the area containing lignite deposits.

Arsenic Concentrations in Groundwater

One of the toxic substances present in the lignite deposits is arsenic. Map 4 in Figure 4 shows the concentration of arsenic in groundwater across the state of Texas. In the south-central and southeastern regions, there are areas of high arsenic concentrations that also contain lignite deposits. The greater concentrations present in the southern part of the state could be a factor that

influences mortality rates in the region. There are also high concentrations of arsenic in groundwater in the southern part of the Texas panhandle.

Gender as a Factor

The state average for age-adjusted mortality rates for kidney and renal pelvic cancers in men is 6.171 deaths per 100,000. This rate is about 2 deaths per 100,000 greater than average for both genders. The geographic distribution of the disease for men does not differ significantly from that of kidney and renal pelvic cancers for both genders. The state average for women is 2.840 deaths per 100,000. This rate is about 1.5 deaths per 100,000 lower than the state average. There is no discernable spatial pattern for mortality from renal pelvic cancers in women.

Race/Ethnicity as a Factor

In Texas, Blacks experience an age-adjusted death rate of 4.41 deaths per 100,000. The counties with above-average rates for Blacks are located in the eastern portion of the state. For Whites, the state average is 4.279 deaths per 100,000. The spatial distribution for Whites resembles that of the entire population. The state average for Hispanics is 4.417 deaths per 100,000. The counties that experience above-average rates for Hispanics are located in South Texas along the Texas-Mexico border where there are larger populations of Hispanics. There was a significant, positive correlation between the percentage of the population that is Black and mortality rates ($r = 0.147$, two-tailed sig. = 0.019). The correlations between percentage of the population that is Hispanic and percentage of the population that is White were not significant.

Socioeconomic Status as a Factor

There is a significant, positive correlation between the 1999 median income and age-adjusted mortality rates ($r = 0.150$, two-tailed sig. = 0.017). There was no significant correlation between the percentage of the population with at least a ninth-grade education and age-adjusted mortality rates (two-tailed sig. = 0.199).

Change in Age-Adjusted Mortality Rates Over Time

The state average for age-adjusted mortality rates for both kidney and renal pelvic cancers for the 1980–1984 period was 3.7 deaths per 100,000. There was a cluster of counties in the northeast part of the Panhandle that had above-average mortality rates. The counties with high rates are mainly in the eastern and northern regions of Texas. Throughout the study period, the state average mortality rates continually increased. From 1995–1998, the average was 4.7 deaths per 100,000. The increase of about 1 death per 100,000 for the study period was accompanied by a shift in the geographic distribution. For the 1995–1998 period, there were groups of counties in east and west Texas, as well as in the south along the Gulf Coast, that exhibited above-average rates, whereas before 1995 most of the above-average rates occurred in the northern part of the state.

Conclusion

Although there are many causes of kidney and renal pelvic cancers, there is a possible spatial relationship between age-adjusted mortality rates for these cancers and lignite deposits. A considerable portion of the counties with above-average rates also contained lignite deposits. Some of the counties in northeast Texas that have above-average mortality rates border Louisiana counties that have been shown to have high rates of renal pelvic cancers associated with compounds leached from lignite deposits.

Several groups were found to be more at risk of developing these cancers. Men are twice as likely as women to suffer mortality from kidney and renal pelvic cancers. Blacks were found to have a higher risk of developing these cancers than people from other racial/ethnic groups.

From 1980-1998, the state average age-adjusted mortality rates increased and the geographic distribution of age-adjusted mortality rates for kidney and renal pelvic cancers changed. At the beginning of this period, the greatest density of counties that had above-average mortality rates occurred in the northern part of the state. After 1990, the number of counties in the south, east, and west that exhibited above-average mortality rates began to increase. This increase is a phenomenon that requires more research to explain.

Suggestions for Further Research

To provide a quantitative analysis, water samples must be taken and analyzed to determine if there are high concentrations of nephrotoxic compounds that are also associated with lignite deposits. This sampling is necessary to determine if the lignite deposits are affecting the mortality rates from kidney and renal pelvic cancers. To explain the change in the geographic distribution of the cancers from 1980-1998, it would be beneficial to have data that represent the changes in toxic compound concentrations found in groundwater. Analyzing the data by looking for changes in concentrations might help to better understand the change in the distribution of kidney and renal pelvic cancers. It would also be beneficial to find the exact locations of the lignite deposits in Texas instead of using a continuous lignite model.

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Figure 1. Map 1: Age-Adjusted Mortality Rates by Texas Counties for Kidney and Renal Pelvic Cancers Occurring in Both Sexes

Figure 2. Map 2: Age-Adjusted Mortality Rates by Texas County for Kidney Cancers Occurring in Both Sexes

Figure 3: Map 3: Age-Adjusted Mortality Rate for Texas Counties for Renal Pelvic Cancer in Both Sexes

Figure 4. Map 4: Arsenic Concentrations in Texas Groundwater