Correlation Between Urbanity and Heart Disease Mortality in U.S. Counties

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Heart disease is the number one cause for deaths each year in the U.S. The mortality rates for this disease are documented in rural and urban counties. It is necessary to understand the overlooked factors that contribute to heart disease mortality. One of the most understudied factors that has an effect on the mortality rates for heart disease is the urbanity of a county. For a disease that kills masses of people each year, it is critical to thoroughly study every factor that leads to these mortality rates. Therefore, the researchers must study the urbanity or rurality of a county to see if these regions correlate with heart disease mortality rates. In order to gather and efficiently utilize all of the necessary data, the researchers will run a secondary quantitative analysis where data from accurate sources will be used in a t-test. All 3,143 counties in the U.S. were each analyzed to determine the most rural and the most urban county in each state, meaning that a total of 100 counties were used for the t-test. For this research paper, the researchers have decided that urban counties will represent counties that have a population of 10,000 people or more while rural counties will represent counties that have a population that is under 10,000. To the researchers' surprise, the mortality rates for heart disease in rural counties was higher than the mortality rates in urban counties. Sample sizes for this study included every recorded individual from all counties in the U.S., and the mortality rates were scaled to be measured out of 100,000 people. The average mortality rate in rural counties throughout the U.S. is 352.3026 while the average mortality rate in urban counties is 317.0579. This means that the difference between the mortality rates is significant to an extent, specifically a difference of approximately 35 on average per county. By utilizing a t-test and analyses conducted with STATA 15.1 (StataCorp, College Station, TX), the researchers were able to determine these results. There is clearly a correlation between the level of urbanity and mortality rate in a county for heart disease, just as the researchers hypothesized. To gather the necessary data, the researchers will use a dataset from the CDC. Adults ages 35 and older were used from every county in the U.S. These adults included Whites, Blacks, Indians, Asians, and Pacific Islanders. The CDC was able to gather this data through different communities like doctors' offices, hospitals, and laboratories. There are multiple differing factors that contribute to the specific mortality rates by heart disease in both urban and rural areas, but no notable confounding variables had significantly altered the outcomes of the results. The understudied issues in rural counties has, however, contributed to the overall results of this study. Heart disease mortality rates in relation to the urbanity of a county/region is a topic that should be studied more often to find more efficient ways of potentially reducing the overall mortality rate.

Introduction

Heart disease is the leading cause of death in the United States[1,2]. Every 33 seconds, someone dies because of heart disease or cardiovascular disease[3]. In 2021 approximately 695,000 people in the U.S. died from heart disease, which accounted for 1 in every 5 deaths[4]. Since so many individuals suffer from these diseases each year, there is a plethora of health care services that need to be utilized and this can become costly for the patients. Heart disease costs the United States about $219 billion each year[5]. As the impact of heart disease is incredibly grand, the researchers will evaluate several contributing factors. The ultimate goal is to determine the following question: is there a significant correlation between the urbanity/rurality of a county, and the heart disease mortality rate? It is imperative that the researchers thoroughly investigate this question since the degree of urbanity having a profound effect on mortality rates is an overlooked issue. Before any significant research was conducted, the researchers hypothesized that there would be a relatively strong correlation between heart disease mortality rates and the degree of urbanity of a county, with urban counties having higher mortality rates than rural counties on average.

There are multiple factors that may contribute to death rates by heart disease across the world, and these factors may be of great interest to the international community. These factors may be indirect and direct. A few notable indirect factors include particle pollution, secondhand smoke exposure (which is a variation of particle pollution), excessive alcohol use, and physical inactivity[6,7]. Direct factors include high blood pres-

sure and high cholesterol. While direct contributors to heart disease have been widely studied, indirect factors have often been overlooked. In particular, indirect factors related to how urban a location is, have been severely understudied.

It is also possible for people to be indirectly affected by pollution, since these pollutants have an impact on the surrounding environment. Some effects of the environmental harm include: lakes and streams becoming acidic, sensitive forests and crops getting damaged, and changing the diversity of ecosystems[8]. Pollution is one of the more prominent problems that continues to exponentially worsen over time[9]. In 2016, ambient air pollution (air pollution in outdoor environments) was responsible for the deaths of around 4.2 million people[10]. Globally, this air pollution is responsible for 17% of all ischemic heart disease deaths. Pollution is also a critical issue in the United States, and it exists in both urban and rural locations. In the next few paragraphs, a discussion over rural and urban counties will be done.

Urbanity refers to the metropolitan lifestyle—cities, towns, and fairly populated regions[11]. Urban locations tend to have worse air quality compared to rural locations due to the higher populations. Pollutants like sediment, oil, grease, road salts, and toxic chemicals from motor vehicles have all been known to make recreational areas hazardous for overall health[12]. Microscopic pollutants that are less than 10 micrometers pose the greatest threat since they can easily enter a person's lungs, and then eventually their bloodstream. This kind of exposure is known to cause irregular heartbeats, non-fatal heart attacks, decreased lung function, and irritation of the airways. Individuals that are suffering from heart disease are at a greater threat of being negatively affected by these pollutants[13].

Rural locations refer to regions that are related to or include the countryside. In the United States, they typically have less than 500 people per square mile[14]. Rural regions have less pollution outdoors compared to urban regions, but the pollution from urban communities can be carried to rural areas which would affect the health of residents in rural areas. When it comes to indoors, rural residents may be worse off compared to urban residents. Rural households disproportionately rely on smoky biomass fuels for necessities like cooking and heating[15]. Research done by the Environmental Protection Agency (EPA) found that increased exposures to higher contents of PM2.5 (a particle pollutant) can trigger cardiovascular disease, related heart attacks, and eventually lead to death. This signals that a correlation potentially exists between PM2.5 and death rates by cardiovascular disease[16]. On average, this particle pollutant is more prevalent in urban locations in comparison to rural areas[17].

As for lifestyle choices, a study from the National Library of Medicine shows that students living in rural areas exhibited healthier habits compared to people living in urban areas. Students from rural locations spent less time on computers and had lower video game exposure, had higher levels of physical activity, and had shorter sitting down time on average[18].

Despite these studies showing that various differences between rural and urban locations contribute to their differential mortality rates due to heart diseases, a report done by the American College of Cardiology suggests that there is little known about geographic variation in relation to cardiovascular death rates[19]. The researchers were, however, able to find out that the risk of suffering from heart failure was 19% higher in rural residents compared to people living in urban locations[20].

In the U.S. the variability of death rates due to heart disease in each state may be different due to the variability in each state's amount of urbanization. Therefore, the main goal of this research study is to find out if there is a correlation between the urbanity/rurality of a location and death rate by heart disease. Our independent variable is the urbanity or rurality of a location, while the dependent variable is the heart disease mortality rates.

Methods

The researchers ran a secondary quantitative analysis to get to the bottom of the goal. To find a potential correlation between the two variables, we needed a reliable data source. The Centers for Disease Control and Prevention (CDC) provides an abundant amount of data sources for cardiovascular/heart related death rates. We used a particular data file from the CDC containing a three-year average (from 2016-2018) of heart disease mortality rates for every county in the U.S. Asians and Pacific Islanders, Whites, Blacks, Hispanics, and American Indians were all used for the data, and these adults were either 35 years old or older. The public health data collected by the CDC comes from different communities such as hospitals, laboratories, doctors' offices, and anywhere that a person receives healthcare. This could also be at home, which significantly reduces the sample selection bias. For this particular file, data was collected over the course of three years from 2016 to 2018. The main source of data can be traced back to the National Vital Statistics System. The correlation between the variables represented in the data assures the validity and reliability of the file since similar datasets exhibited the same trends. However, since this dataset includes mortality rates for individuals that are of age 35 or older, it places some bias on the outcome of the results since there could be people younger than 35 dealing with heart disease mortality. Variables that will be analyzed in depth include the population of counties, and the corresponding heart disease mortality rates. In the documentation of this data, every individual's name was kept anonymous. Information like the exact age of people used for the dataset, and where they live are confidential. For the urbanity and rurality measures, a system for output areas needs to be established. Counties that have a popula-

tion under 10,000 people are considered rural, while counties with a population of 10,000 people or more are considered urban. Counties are "excessively urban" if the population is over 1,000,000. Likewise, counties that are "excessively rural" will have populations of 5,000 or less. Our output areas only include the most populated (urban) county and the least populated (rural) county from each state in the U.S. The mortality rates from the dataset are measured on a scale per 100,000 people. Once we run the two-sample t-test, we can analyze the differences between mortality rates in urban and rural locations for heart disease. The results will provide further gateway for future research that could potentially solve one of the most overlooked issues in the United States while confirming that there is indeed a significant correlation between heart disease mortality rates in urban and rural locations, as the p-value ends up being 0.0208. Before the results are run, the researchers believe that the urban counties will have a greater mortality rate for heart disease compared to the rural counties. This hypothesis was made based on the factors present in these different counties. Highly populated areas that contain lots of ambient pollution are known to negatively affect those with heart disease. The utilization of biomass fuels in rural households also targets people suffering from heart disease, but the environmental damage found in most urban areas helped the researchers solidify their hypothesis.

Results

After organizing the data from the CDC file, we ran a t-test and all analyses were conducted using STATA 15.1 (StataCorp, College Station, TX). With a confidence interval of 95%, there is little to no uncertainty associated with the estimated results. The average mortality rate per 100,000 individuals in rural counties was 352.3026. When it came to the urban results, the average mortality rate per 100,000 individuals was 317.0579. This means that there was a 35.24474 difference between these two regional populaces. The average standard error from the data analyzed was 14.6008, and the total degrees of freedom from the t-test ended up being 37. Across the United States not every rural county had a higher mortality rate compared to the urban counties. It might be the outliers in these counties that appertain to the overall results. For example, in Wake County (an urban region), North Carolina, the mortality rate for heart disease (per 100,000) was 99.99. This statistic is considerably low compared to the rest of the numbers displayed on the urban side. Likewise, in Tensas Parish (a rural region), Louisiana, the mortality rate was 608.2 which is astonishingly high[21]. These outliers can make it substantially easier for mortality rates in rural counties to surpass the mortality rates in urban counties on average. If more of these extreme outliers existed in the data, the overall p-value of 0.0208 would have potentially been much lower, further strengthening the statistical significance of the correlation. The standard deviation was also greater across the rural mortality rates. Rural counties had a standard deviation of 94.24116 which is greater in comparison to the standard deviation of 87.60187 for the urban counties. A t-value of -2.4139 indicates that there is a significant correlation between the averages of each mortality rate. Although the results presented do not give further insight to data separated by demographic variables such as age, race, and gender, the researchers can compare the results of this study to existing literature on the same topic that also covers the demographic variables. A study from "AHA Journals" says that Black adults are twice as likely to die from cardiovascular disease compared to White adults. They also found out that American Indian individuals are 1.5 times more likely to develop a coronary heart disease in comparison to White individuals[22]. Another study done from the CDC determined that heart disease death rates were greater in men compared to heart disease death rates in women, from 2009 - 2019. The death rates for men were around a rate of 204 - 230 per 100,000 people throughout this 10 year time period, while the death rates for women were around 135 to 147 per 100,000 people. The CDC was also able to gather heart disease death rate data on different racial groups including Blacks, American Indian or Alaska Native, Whites, Hispanic or Latino, and Asian or Pacific Islander. This data was also scaled per 100,000 people. The Blacks had the greatest heart disease death rates on average, ranging from around 210 to 240. Whites displayed the second highest mortality rates, ranging from 170 to 190. American Indian or Alaska Native came in at third, averaging from 140 to 160. Hispanics came in fourth, with average mortality rates ranging from 120 to 145. Asian or Pacific Islanders had the least amount of mortality rates for heart disease of all the racial groups analyzed, with their rates ranging from 90 to 105[23].

Discussion

The results from the t-test surprisingly indicate that mortality rates by heart disease are higher in rural counties compared to urban counties, and by a considerable amount too. The marginal difference of -35.24 shows that people are at higher risk of dying from heart disease if they reside in rural locations. It is also possible that the results could be numerically biased because of the standard deviations. Standard deviations of 94.24116 and 87.60187 imply that mortality rates for heart disease are anything but constant. Counties like Wake County and Tensas Parish represent outliers that can easily alter the outcomes by great margins. Regardless, it is still clear that rural counties have higher heart disease mortality rates overall. It is entirely possible that the outcome of the results were heavily influenced by the sample sizes. Urban counties can be scaled beyond tens of thousands of people, while rural coun-

Variables	Obs	Mean	Std. error	Std. Dev
Urban Countries	38	317.0579	14.2109	87.60187
Rural Countries	38	352.3026	15.28793	94.24116
Differences	38	-35.24474	14.6008	90.00539

Table 1 Descriptive Statistics

Paired differences			95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
-35.24474	90.00539	14.6008	-64.82877	-5.660701	-2.4139	37	0.208

ties are only "rural" if the population doesn't exceed 10,000.

Comparing urban and rural locations resulted in an overall t-value of -2.4139 which would easily deny any null hypotheses about the correlation of heart mortality rates compared to these regions. This leads the researchers to question, what is it that rural counties have that cause greater mortality rates compared to urbanized counties? Earlier in this research paper it was declared with evidence that rural households rely on biomass fuels quite often for their convenience. The biomass fuels themselves are a direct contributor to poor air quality as pollution is released from the result of burning them, and the effects from this could be worse than the pollution in urban areas. Since there is a substantially higher number of hospitals in urban areas it would make access to healthcare more convenient for people living there. The less convenient access to healthcare to prevent these heart disease deaths in rural areas could be a direct factor that contributed to the overall outcome of the results. The transfer of pollution from urban areas to rural areas could be another explanation that buttresses the researchers' findings.

Future research should cover and analyze the different aspects of urban and rural counties, specifically information that pertains to individuals' health. Because of the identified differences between the two types of counties, for health on average, interventions for less screen time and more physical activity should be enforced. When physical activity becomes a norm for everyone in the U.S., more research should be done where heart disease death rates from the future are compared to the heart disease death rates from the past. It is important to identify if there will still be any significant correlation between the urbanity of a region and the mortality rate. In the end, the researchers were correct in hypothesizing that there would be a significant correlation between urbanity and heart disease mortality rates. The results were, however, able to prove that the researchers were wrong in hypothesizing that urban counties would have higher mortality rates on average in comparison to rural counties.

Conclusion

Heart disease has been the leading cause of death in the United States since 1921[24]. Cancers, respiratory diseases, diabetes, and dementia don't even come close. The range and multitude of factors that can cause heart disease deaths seem to be everywhere, while pollution remains one of the most prominent factors. As heart disease mercilessly takes away lives, the mortality rates only continue to get worse[25]. On a global scale over a 30 year time period, from 1990 to 2021, deaths from heart disease have increased from 12.1 million to 20.5 million. This enormous jump in mortality rates is an increase of about 60%. There are multiple studies being done on heart disease and heart disease mortality rates, but future studies should look into the relationship of urban/rural counties and heart disease. Unfortunately, there has been a lack of research done that compared heart disease mortality to rural and urban locations. This research outlined and defined urban counties as regions that have a population of 10,000 people or more. Counties that had a population under 10,000 were considered rural. Prior to the quantitative data analysis, the researchers predicted that urban locations would have higher heart disease mortality rates on average due to factors like higher population densities and hazardous air pollution. We were perplexed by the t-test results which show rural counties had an average heart disease mortality rate that was greater than the mortality rate given for urban counties. There was also a considerable margin between the two. If the urbanity of a county was excessive, the heart disease mortality rate (on average) would be low. Consistent use of biomass fuels along with a lack of convenient healthcare are issues that rural regions face that contribute to their high mortality rates. The researchers were able to meet their objective of determining the fact that

there is a strong correlation between the urbanity of a county and the associated heart disease mortality rate of the region. There were primary factors of causation that determined the relationship between the level of urbanity and mortality rates, with the "less urban" and "more rural" counties having higher mortality rates. As mentioned previously, biomass fuels represent one of these factors, but another major factor is physical activity. There is a lack of physical activeness in rural counties on average in comparison to urban counties. This factor will cause the mortality rates to be higher in rural areas to be greater. In the future heart disease in relation to the urbanity of a location should not be overlooked. If future studies are done on this topic there could be more discoveries that eventually aid the potential deterioration of heart disease mortality rates.

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