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Will Electric Vehicles Reduce Cancer and Heart Disease Mortality?

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Abstract

The contribution of vehicle emissions to cancer and heart disease mortality in the US is seldom recognized in public policy. To estimate the potential for death reduction through reduced emissions, a least-squares regression model of major known and suspected risk factors was developed, accounting for collinearity among predictors. Data on daily kilometers driven in 822 urban US counties derived from GPS and cell phone movement in 2020 were matched to age-adjusted rates of cancer and heart disease mortality in 2021–2023, each separately for men and women, percent who smoke cigarettes, percent heavy alcohol use, ≤ 2.5PM air particulates, percent African American, inequality, and population density. The calculated regression coefficients of emissions and smoking were then set to zero separately. The predicted rates were converted to the number of deaths for each county and were summed. When the totals without emissions or smoking were summed and subtracted from the numbers that occurred, more than 600,000 deaths annually were found associated with vehicle kilometers and smoking, nearly evenly distributed between the two risk factors. Replacement of fossil fuel-powered vehicles with electric ones is likely to reduce premature deaths from cancer and heart disease.

Will Electric Vehicles Reduce Cancer and Heart Disease Mortality?

Some 60 years ago, scientists discovered carcinogens such as aldehydes and polycyclic aromatic hydrocarbons in the exhaust of vehicles powered by fossil fuel combustion [1-5]. Epidemiologists found that cancer rates were higher in areas where concentrations of these pollutants in ambient air were higher [6,7]. Urban areas with more registered vehicles had higher cancer mortality rates [8-9]. Studies of black carbon (BC), oxides of nitrogen (NOx), and carbon monoxide (CO) near and away from roads indicate increased risk of heart-lung diseases [10]. Separate US Surgeon General reports on air pollution, smoking, cancer, and heart disease in the 1960s acknowledged the likely effects of both, but the smoking report received the most attention. Scientists debated which was the most important factor contributing to lung cancer, smoking or air pollution [11].

New technology for measuring vehicle use in local areas was used in this study to examine the correlation of such use with death rates, controlling statistically for smoking, other air pollution, alcohol use, obesity, and socio-demographic factors. Inclusion of these factors is based on evidence from the research literature that they increase the risk of cancer [12-13], but there is less consensus on the role of alcohol and obesity in heart disease [14-15]. Particulate concentration per unit volume of air is considered a major factor in heart disease [16]. Although the characteristics of cancer cells differ among types and anatomical sites, cigarette smoking is linked to most of them [17]. This study was conducted to determine whether these factors could predict differences in age-adjusted, gender-specific rates of cancer and heart disease among US counties with populations over 50,000, and if so, what difference adoption of zero-emission electric vehicles would make.

Methods

The research plan was to collect data on US counties regarding cancer and heart disease age-adjusted death rates, along with risk factors that are either known or hypothesized to influence these rates. The aim was to identify the least squares regression model that the data fit the best for predicting mortality rates and to assess the potential for prevention by modifying vehicle emissions. The correlations among risk factors were examined to exclude highly correlated variables that could distort regression coefficients and their predictive power. The exclusions are noted in the results section. The regression model was used to predict the number of deaths expected if no one smoked, and separately if vehicle emissions were zero. The calculated regression coefficients of emissions and smoking were set to zero separately. The predicted rates were converted to the number of deaths for each county, and their sum was compared to the total number of deaths that occurred.

Data on age-adjusted heart disease death rates, averaged for 2021-2023 by gender, were obtained from the Centers for Disease Control and Prevention (CDC) [18] and for cancer from the National Cancer Institute [19]. The percentage of people who smoked cigarettes in 2012, separated by gender, and percent obese and percent heavy alcohol use, is from county estimates, based on the CDC Behavioral Risk Factor Survey [20]. Particulate matter in air samples (≤ 2.5pm) were copied from the University of Wisconsin Population Institute [21]. The Gini inequality index, percent African-American, population per square mile (density), and population by gender were obtained from the US Census Bureau [22].

In 2020, Streetlight Data, a company that uses cell phone and GPS data to track vehicle movement, provided the author with daily data for each US county from January through July 31. The sum of daily miles driven in each county over those seven months was used to estimate exposure to vehicle emissions, converted here to kilometers. Independent researchers found that the R^2 between data from traffic counter sites and Streetlight's estimates at those sites is 0.98 [23,24]. The daily kilometers accumulated in each county were divided by the population. The skew in the distributions of death rates, kilometers per population, and population density was reduced by taking logarithms of those variables.

Results

The use of kilometers driven in part of one year assumes that the data reflect differences in vehicle use among the counties in previous years. Since the data were gathered partly during the COVID-19 pandemic, the effect of travel restrictions in some states was of concern. A plot of the trend in the daily kilometers per population (Fig. 1) indicates that states without restrictions had similar reductions in travel as those without.

Only counties with more than 50,000 residents were included. Data on all variables were available for 822 counties, containing a total population of 246.8 million, 74 percent of the US population. The means and standard deviations of the included variables are in Table 1.

Table 1
Means and standard deviations of included variables

	Mean	Standard Deviation
Log Male Age-adjusted Cancer Death Rate	5.203	0.154
Log Female Age-adjusted Cancer Death Rate	4.880	0.129
Log Male Age-adjusted Heart Death Rate	5.421	0.241
Log Female Age-adjusted Heart Death Rate	4.926	0.254
Log Kilometers/persons	9.247	0.340
Percent Male Smokers	23.794	3.999
Percent Female Smokers	20.066	4.385
Percent Heavy Alcohol Use	18.656	2.360
Percent Obese	36.780	4.980
Percent African American	10.181	12.174
Inequality (Gini Index x 100)	4.571	6.207
Log Population Density	4.464	1.239
< 2.5PM air particles	8.423	2.466

The correlations among potential predictor variables are presented in Table 2. Vehicle kilometers per population are not strongly correlated with other risk factors, so there is no need to be concerned about collinearity. The major concern for the distortion of regression coefficients by collinearity is the high correlation between percent smokers and obesity. Fear of weight gain is often given as an excuse to continue or resume smoking [24]. In the US, women attending a smoking cessation clinic who were concerned about weight said they would resume smoking if they gained 8–10 pounds, and men said 10–12 pounds [25]. When obesity was included in the regression analysis, the fit of the distributions of predicted deaths and actual deaths was substantially inferior to the fit without obesity in the equation, so the latter is presented here.

Table 2
Least-squares correlations among potential predictor variables

	Log Kilometers per Person	Percent Heavy Alcohol Use	Percent Obese	Percent African American	Inequality	Log Population Density	< 2.5PM air particles
Log Kilometers per person	1.00	0.00	.14	0.00	− .09	-0.32	0.14
Percent Male Smokers	0.14	-0.29	0.71	0.28	0.07	-0.27	-0.12
Percent Female Smokers	0.16	-0.10	0.61	-0.01	-0.07	-0.27	-0.18
Percent Heavy Alcohol Use			-0.30	-0.43	-0.20	-0.06	-0.06
Percent Obese				0.26	0.21	0.45	-0.08
Percent African American					0.34	0.31	-0.02
Inequality						0.17	0.04
Log Population Density							0.05

The regression coefficients and standard errors of the chosen predictor variables are shown in Table 3.

Table 3
Logged cancer and heart disease age-adjusted death rates per 100,000 population predicted by the prevalence of risk factors in 822 US counties, 2021–2023

	Log Male Cancer Death Rates	Log Female Cancer Death Rates	Log Male Heart Disease Death Rates	Log Female Heart Disease Death Rates
Log Kilometers per person	.036 (.006)	.039 (.005)	.069 (.010)	.099 (.012)
Percent Smoke by Gender	.023 (.001)	.017 (.001)	.034 (.002)	.029 (.002)
Percent heavy alcohol use	.009 (.002)	.002 (.001) NS	− .018 (.003)	− .029 (.003)
≤ 2.5PM air particulates	.004 (.001)	.007 (.001)	.007 (.002)	.008 (.002)
Percent African American	.002 (.000)	.003 (.000)	.001 (.001) NS	.003 (.001)
Inequality	− .022 (.005)	− .019 (.004)	.043 (.008)	.041 (.009)
Log population density	− .028 (.003)	− .018 (.002)	− .016 (.005)	− .018 (.005)
Intercept	4.334	4.237	4.133	3.785
R^2	0.66	0.65	0.56	0.55

NS = not statistically significant at $p < .05$, two-tailed test.

Both cancer and heart disease death rates were higher for each gender in counties where more miles per person were accumulated, a greater percentage of persons of each gender were smokers, and more particulate matter was measured in the air, as hypothesized. Counties with a higher percentage of African Americans had higher death rates, but the coefficient for male heart disease was not statistically significant. Cancer death rates were higher in counties with more heavy drinkers, insignificantly for females, but heart disease was lower in association with percent heavy drinkers. Cancer rates were lower for both genders in counties with more inequality, but heart disease rates were higher in association with inequality. Death rates were consistently lower in counties with higher population density.

Table 4
The percent reduction in the annual expected heart and cancer deaths if vehicle emissions or smoking were zero.

	Observed	Model Predicted	Zero Emissions	Percent Reduction	Zero Smoking	Percent Reduction
Male Cancer	206,076	204,228	149,847	27	123,658	40
Female Cancer	148,760	148,612	106,254	29	110,377	26
Male Heart Disease	258,100	256,236	141,518	45	121,735	45
Female Heart Disease	152,225	151,491	64,560	58	90,919	40
Total	765,161	760,567	462,179	39	446,689	41

Table 4. shows the estimated death reductions if either smoking or vehicle emissions were zero. The fit of observed to predicted deaths was extraordinary. The R^2 for each comparison was 0.98 or higher. The potential reduction of women's heart deaths given zero emissions is greater than that for zero smoking. Male cancer deaths would be lower with no smoking than with zero vehicle emissions. In total, either no vehicle emissions or no smoking would potentially reduce deaths by about 40 percent.

Discussion

Organizations focused on cancer and heart disease often assert that cigarette smoking is the most preventable cause of cancer and heart disease mortality [26–28]. The results presented here, when considered in the context of the effectiveness of anti-smoking campaigns and policies and the potential for zero vehicle emissions, cast doubt on that conclusion. The fatal consequences of cigarette smoking and vehicle emissions are roughly equivalent, about 300,000 deaths per year each in the counties in this study. Combined with rapidly increasing deaths associated with global warming [29], the effects of emissions are likely to increase.

Although information campaigns, increased taxes on cigarettes, and bans on smoking in most public areas had a major effect on reducing smoking [30], more than one in 5 adults in the US admits to smoking in recent years [20]. The studies of concern for weight gain by smokers urged to quit suggest that it is one of the reasons [31]. The availability and popularity of weight-loss drugs could contribute to a reduction in the concern. According to a watchdog group, the depiction of smoking in popular movies, TV comedies, and dramas has increased dramatically, raising the possibility that smoking will become "cool" again [32].

The evidence of global warming, mainly driven by fossil fuel combustion, has led many governments to promote and subsidize electric-powered vehicles with zero emissions. Sales growth in the US has been less than half that in Europe and China [33], and is likely to slow given the hostility to evidence of global warming in general and to electric vehicles in particular by the President and leaders of his political party elected in 2024 [34]. Researchers have noted that vehicles without emissions will substantially reduce deaths [35], but this has been denied or ignored. However, the main publicity about potential health effects of electric vehicles has focused on carcinogens in batteries [36], which do not escape except in fires, possibly in severe crashes, and if not disposed of properly when the vehicles are junked.

In this analysis, estimated heavy alcohol use is associated with increased cancer mortality risk among males but not females, and is associated with reduced heart disease mortality risk for both sexes. The latter seems implausible as a causal nexus, and excessive alcohol use is associated with road deaths, suicides, and homicides [37]. Unfortunately, CDC does not include moderate alcohol use in its county estimates, so nothing new from this study can be said about the claim that moderate drinking reduces heart disease risk.

A limitation of this study is the use of aggregated data, which can bias estimates if the people who behave in a certain way are not the same as those who died. Also, the CDC Behavioral Risk Factor Survey is limited by the tendency of some people to misreport disapproved behavior and by a response rate to their telephone surveys averaging about 50 percent [38]. This limitation applies to the smoking, alcohol, and obesity data used in this study. Nonetheless, the smoking data predict substantially higher death rates in counties where higher smoking prevalence is reported in a well-fitted statistical model.

In the case of air pollution from vehicles and other sources, everyone is exposed to varying degrees. Higher death rates in counties with more vehicle kilometers driven per capita suggest that large reductions in deaths are achievable by reducing the burning of fossil fuels in motor vehicles.

Declarations

Ethical approval:

This research used only publicly available statistics from the internet and from a private company that donated vehicle travel data. No individuals were contacted, and no ethical approval was required.

Consent to participate:

No individuals were contacted.

Consent to publish:

Not applicable.

Author Contribution

Leon S. Robertson is the sole author who conceived and implemented the project without assistance.

Data Availability

The data can be downloaded at: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/8VIH3B&version=DRAFT

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Figures

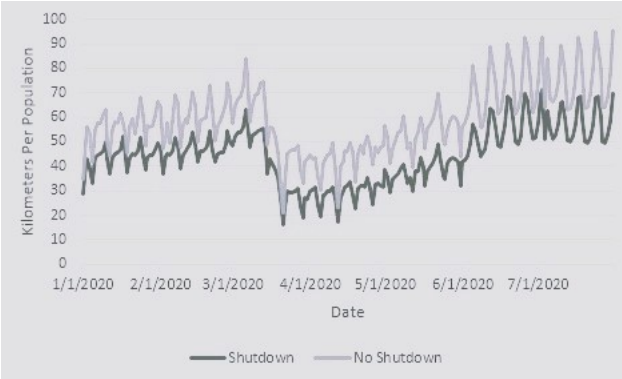


Figure 1

Comparison of daily kilometers per population among states that restricted travel (shutdown) and others during the COVID-19 pandemic emergency