Association Between Geographic Concentration Of Chiropractors In 2008 And Circulatory Disease Death Rates In 2009

J Hart

Citation

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Abstract

Introduction: Prior research indicates a possible relationship between chiropractic care and improved cardiovascular function. The present study further explores this possible relationship at the population level, comparing circulatory disease death rates (CDDR) to geographic concentrations of chiropractors (GCC). For further comparison purposes, geographic concentrations of osteopaths (GCO) and medical doctors (GCM) were also included, along with smoking rates. The purpose of the study was to compare their relative strength of association with CDDR, with GCC being the main predictor of interest.

Methods: Using an ecological design, age-adjusted CDDR per 100,000 for 2009 in the 50 states and District of Columbia was compared to GCC, GCO, GCM and smoking rates in 2008. The comparisons were made for two race groups: whites and all races.

Results: GCC showed the strongest and most consistent beneficial relationship with CDDR compared to GCM and GCO. Smoking revealed an adverse relationship with CDDR.

Conclusion: In this study, as geographic concentrations of chiropractors increased, circulatory disease death rates tended to decrease.

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INTRODUCTION

A number of studies have indicated that cardiovascular function improves following the delivery of chiropractic care. Some of these studies showed that adjusting in different areas of the spine evoked different heart rate variability responses. (1-2) A practice-based study revealed that following chiropractic care, a decreased (improved) resting heart rate and an increased heart rate variability (improved) was observed. (3) Other studies have revealed similar improvements in cardiovascular function. (4-6) These improvements are due ostensibly to improved nervous system function that is expected to follow chiropractic care of the spine. (7)

An alternative research design, where individual exposures are unknown though having an advantage of including entire populations, is the ecological design. This approach has been used in previous chiropractic research, where geographic concentrations of chiropractors (GCC) were compared to rates of stroke (8) and hypertension deaths. (9) A similar study compared GCC in 2004 to a number of health outcomes for years just prior to 2004, among which was the outcome of cardiovascular disease death rates. (10) That study found an inverse correlation between GCC and the cardiovascular death rates, where as GCC increased, heart disease death rates tended to decrease. (10) Another similar study used number of persons in the general population per chiropractor in the U.S. by state as the GCC metric, which was compared to 2007 heart disease mortality rates. (11) That study also found an inverse relationship between the GCC and heart disease death rates. The metric used in the present study (number of DCs per 10,000 population) is, in the author's view, a more reader-friendly metric compared to the aforementioned metric (population per 1 DC).

Since the scientific method requires that previous studies should be verified with future studies, (12) the present study continues with this line of inquiry, comparing more recent years of GCC and focusing on a related outcome - of circulatory disease death rates (also for more recent years). Moreover, ongoing study in this area will help to see if there are any new emerging patterns over time between GCC and death rates from particular cardiovascular causes in the U.S. This approach is similar to the ongoing reporting of death rates each year by the CDC according to the various causes of death in the U.S. For comparison purposes, three other predictors were included. Since death rates tend to differ by race, two race group categories were studied: whites and all races. The white race was selected since it has the highest percent in the U.S. for a single race.

The purpose of the study was to continue studying the association between GCC (the main predictor of interest) and cardiovascular type disease death rates for recent years. The hypothesis is that there will be an beneficial relationship between GCC and circulatory disease death rates (CDDR), where as GCC increases, CDDR tends to decrease, as suggested in previous studies. All variables in the study pertain the U.S.

METHODS

The outcome (dependent) variable was age-adjusted circulatory disease death rates (CDDR) per 100,000 persons for each state in the U.S. and the District of Columbia (now referred to as "states"; n = 51) in 2009 for all ages and both genders for: a) whites, and b) all races. (13) The following four predictor (independent) variables were obtained for the study:

Geographic concentrations of chiropractors ("GCC") by state, calculated by: a) dividing total number of active chiropractor licenses in 2008 (14) by population in each state in 2008 as the denominator, (15) and b) then multiplying this number by 10,000 to obtain a rate of chiropractors per 10,000 persons by state. This variable (GCC) was the main predictor of interest in the study. Since active status could include those not actually providing patient care in the corresponding state listed in the source used, a separate analysis was performed using the "resident" classification. Here it was considered that resident licenses may be a more accurate number of chiropractors actually providing patient care in the corresponding state listed. Thirty-two states report data in this format (by residence);
Geographic concentrations of medical doctors ("GCM"). This variable was calculated in the same way as it was for chiropractor concentrations, using the same population numbers for each state that were used for the chiropractor concentrations as the denominator, as follows: a) dividing number of total active patient care medical doctors in each state in 2008 (15) by population in each state in 2008, (15) and b) then multiplying this number by 10,000 to obtain a rate of MDs per 10,000 persons by state.
Geographic concentrations of osteopaths ("GCO"; doctors of osteopathy), also calculated the same way as GCC and GCM, using the same population numbers in the denominator, as follows: by dividing the total number active patient care osteopaths in each state in 2008 (15) by the total population in each state in 2008 (15), and then multiplying by 10,000 to obtain a rate of osteopaths per 10,000 persons by state;
Percent of adult smokers in 2008 ("smoking") for whites (16) and all races (17).

Analysis

CDDR for each of the two race group categories was compared to the four predictors. Scatter and probability plots were used to determine if the parametric statistics of Pearson correlation and linear regression were appropriate. These tests were considered appropriate for GCC and smoking but questionable for GCM and GCO. The questionable-ness for these latter two were based on: a) an outlier for GCM (in Washington, D.C.) and no relationship observed in the scatter plots for GCO. For GCM, analysis was performed with and without the outlier. The statistically insignificant correlation for GCO (reported below) substantiated that it was not an appropriate predictor to use in linear regression.

Predictors that showed statistically significant correlations were included in linear multiple regression. The unequal variance noted in some of the scatter plots was addressed by using the "robust" option in the software program used – Stata IC 12.1 (StataCorp, College Station, TX) for the 51 observations (states). Two-tailed p-values less than or equal to the conventional alpha level of 0.05 were considered statistically significant.

For the GCC-resident variable, in pair-wise correlation, and in multiple linear regression, the other predictors included the same states, for an n of 32 for all predictors. The GCM outlier (in Washington, D.C.) coincided with non-reporting of GCC-resident data from this jurisdiction (Washington, D.C.). Thus, when performing analysis with GCC-resident, the Washington, D.C. outlier was already removed.

Coefficients for correlation or multiple linear regression are either direct (no sign on coefficient) or indirect (negative sign on coefficient). Direct relationships are expected for smoking, where as smoking increases, so too does CDDR. Indirect relationships are expected for practitioners, where as a practitioner concentration increases, CDDR is expected to decrease. A larger correlation coefficient indicates a stronger correlation. The regression coefficient for each predictor indicates the amount of change in the response variable per one unit change in the predictor. For example, a regression coefficient of -2.0 indicates an inverse relationship, where as the predictor increases by one unit (e.g., one MD increase per 10,000 population), the response variable is predicted to decrease by two units (e.g., 2 fewer deaths per 100,000 population). A larger regression coefficient predicts a larger response variable change per one unit change in the predictor. Relative strength of predictors was assessed by comparing their semi-partial correlation squared values. These values indicate the percent that each predictor contributes to the regression model's R-squared value. The R-squared value is the percent of variability in the response variable (CDDR in the present study) explained by the model.

RESULTS

Figures 1-8 are scatter plots for the predictors versus CDDR for both race categories. Descriptive and summary statistics are provided in Table 1, correlations in Table 2, and multiple linear regression and semi-partial correlation squared values are provided in Table 3. Results are reported by race category.

White CDDR

Correlation

Statistically significant correlations were observed for all predictors except GCO (Table 2). The directions of the correlations were as expected: Indirect (beneficial) for practitioners and direct (detrimental) for smoking. The GCC correlation remained essentially the same when GCC-resident variable was used (same direction for the coefficient, similar coefficient strength, and still statistically significant). The GCM correlation remained essentially the same when its outlier was removed (same direction for the coefficient, similar coefficient strength, and coefficient still statistically significant)

Linear multiple regression

The three qualifying predictors, GCC, GCM, and smoking remained statistically significant, and their directions were as expected (indirect for practitioners and direct for smoking; Table 3). The R-squared value was 0.734 ($p<0.0001$) with predictor contributions to it (the R-squared value), as follows, from strongest-to-weakest: 0.16 ($p<0.0001$) for smoking; 0.10 ($p = 0.0002$) for GCC; and 0.03 ($p = 0.0196$) for GCM; Table 3). These results were essentially the same when the GCM outlier was removed (same directions for coefficients, similar coefficient strengths, and coefficients still statistically significant). When the GCC-resident variable was used, GCM became statistically non-significant in linear multiple regression. In this model (with predictors GCC-resident and smoking), the model R-squared was 0.688 ($p<0.0001$) with contributions to it as follows: 0.24 ($p = 0.0001$) for smoking and 0.10 ($p = 0.0062$) for GCC. All variance inflation factors were less than 3.0, indicating that collinearity between predictors was not a problem. GCC regression coefficients were fairly consistent, ranging from -11.7 to -12.9.

All races

Correlation

Statistically significant correlations were observed for GCC, smoking, and GCM when its outlier was removed (Table 2). The directions of the correlations were as expected. GCC correlation remained essentially the same when using the GCC-resident variable (same direction for coefficient, similar coefficient strength, and coefficient still statistically significant).

Linear multiple regression

In linear multiple regression, with the GCM outlier removed, GCC, GCM, and smoking remained statistically significant and their coefficient directions were as expected. The model R-squared value was 0.690 ($p < 0.0001$) and contributions to it were as follows, from strongest to weakest: 0.17 ($p<0.0001$) for GCC; 0.13 ($p = 0.0001$) for smoking; and 0.03 ($p = 0.0476$) for GCM (Table 3). When the GCC-resident variable was used, GCM was no longer statistically significant, leaving GCC-resident and smoking variables statistically significant. Here, the model R-squared value was 0.692 ($p<0.0001$) with contributions to it as follows: 0.21 ($p = 0.0001$) for smoking and 0.19 (0.0002) for GCC-resident. All variance inflation factors were less than 3.0, indicating that collinearity between predictors was not a problem. The GCC regression coefficients were a bit stronger and wider: -16.3 to -19.1.

DISCUSSION

These results indicate that as GCC increases, CDDR tends to decrease. The beneficial relationship for chiropractors (GCC) was stronger than relationships shown for medical doctors and osteopaths, with the latter (osteopaths) showing essentially no relationship with CDDR.

In linear multiple regression, GCC coefficients ranged from -11.7 to -19.1. This means that as GCC increases by one chiropractor per 10,000 people in the U.S. population, 12 to 19 fewer deaths per 100,000 people in the U.S. are expected.

The author hypothesizes that a reason for the beneficial association for chiropractors is the improved nervous system function that is expected to occur following proper adjustment of the spine. However, a cause-and-effect relationship is not established by this study due to its observational design. Moreover, other plausible explanations such as the advice on healthy lifestyle and diet that many chiropractors also provide (in addition to spinal adjustment) for their patients (17) cannot be ruled out at this time.

It could be said that chiropractors do not see enough patients to make a difference that would manifest itself in findings such as this study shows. Estimates are that chiropractors see approximately only 8% of the adult population in a given year. (18) However, 8% of 304,000,000, the approximate population of the U.S. in 2008 (16), translates into an estimated 24,320,000 chiropractic patients in a given year, which would seem to be a large enough number to make a difference.

Other limitations to the study are: a) its (ecological) design, where individual exposures and results are unknown. Similarly, since the study design is observational, no causal inference can be drawn. However, the design is also a strength in that entire populations are included (e.g., all 50 states and the District of Columbia); b) other CDDR factors were not included, e.g., socioeconomic status, level of physical activity, and obesity. However, the purpose of the study was not to compare the relative strength of GCC to all the well-known CDDR factors, but rather, to compare GCC with the other two practitioner types: GCM and GCO (medical doctors and osteopaths). In this regard, GCC showed the strongest beneficial relationship with CDDR, followed by GCM and then GCO as the weakest predictor; c) an assumption that increased practitioner concentration corresponds to increased numbers of people seen by the practitioners; and d) the numbers of practitioners may not be 100% accurate. For example, approximately (only) 14% of the physician counts (MD and DO) were estimated based on preferred mailing address. In the case of chiropractors, the question of multiple licenses was addressed by using the resident variable where results remained essentially unchanged. Still, it is assumed that these practitioner numbers represent at least a rough and reasonable estimate of the work force for the three provider types in the study.

CONCLUSION

Similar to previous research in this area, the present study revealed an inverse (beneficial) association between geographical concentration of chiropractors and circulatory disease death rates in the U.S. That is to say, as geographical concentrations of chiropractors increased, circulatory disease death rates tended to decrease. This relationship was stronger for chiropractors compared to medical doctors and osteopaths. Smoking revealed an adverse relationship with CDDR as expected. Further study is indicated to verify these findings.

FIGURES 1-8. SCATTER PLOTS FOR PREDICTORS AND CIRCULATORY DISEASE DEATH RATES (CDDR) FOR THE TWO RACE CATEGORIES (WHITE AND ALL RACES). EACH DOT REPRESENTS A U.S. JURISDICTION (STATE OR WASHINGTON, D.C.).

Figure 1

GCC (chiropractors) and white CDDR. As GCC increases, CDDR tends to decrease.

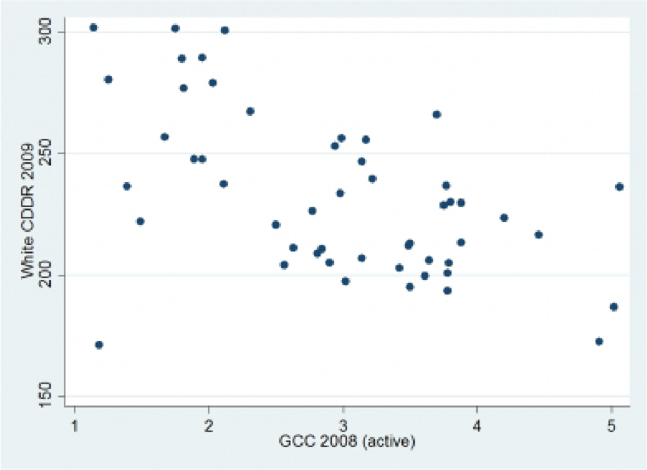

Figure 2

GCC (chiropractors) and all races CDDR. As GCC increases, CDDR tends to decrease.

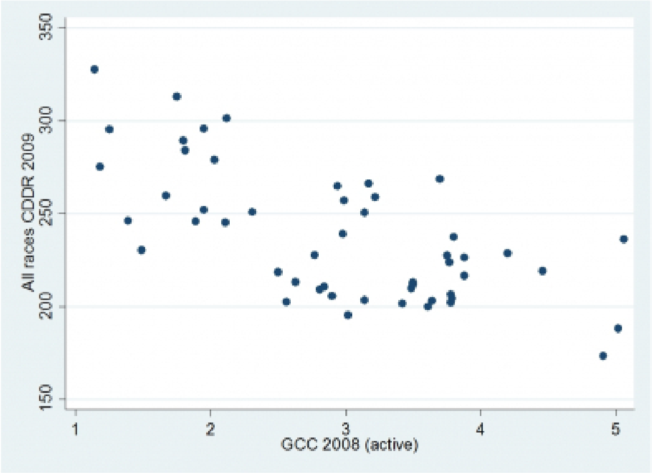

Figure 3

GCM (medical doctors) and white CDDR. As GCM increases, CDDR tends to somewhat decrease. Outlier on the right side of graph represent Washington, D.C.

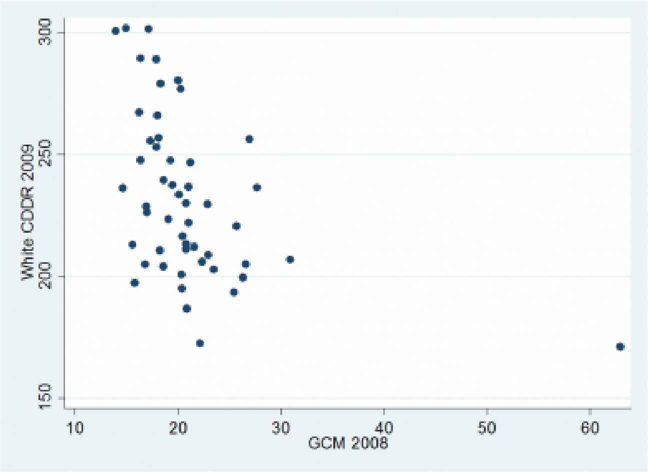

Figure 4

GCM (medical doctors)) and all races CDDR. When outlier (on right side of graph, representing Washington, D.C.) is removed, CDDR tends to somewhat decrease as GCM increases.

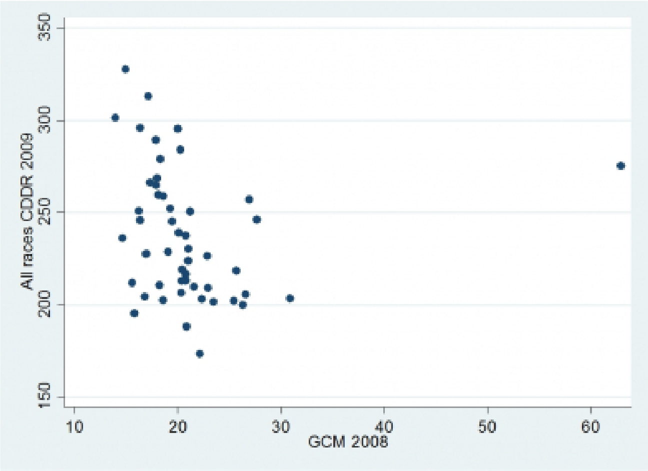

Figure 5

GCO (osteopaths) and white CDDR. No apparent relationship is observed.

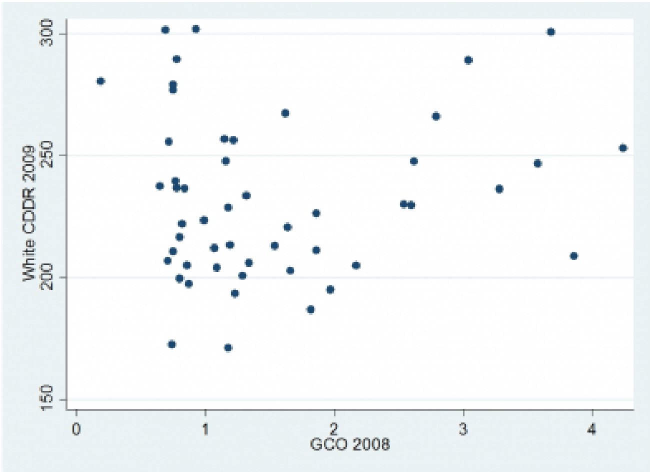

Figure 6

GCO (osteopaths) and all races CDDR. No apparent relationship is observed.

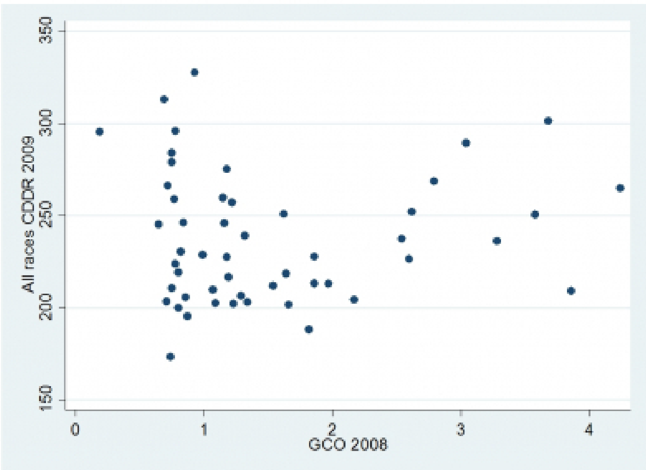

Figure 7

White smoking and white CDDR. As smoking rates increase, so too does CDDR.

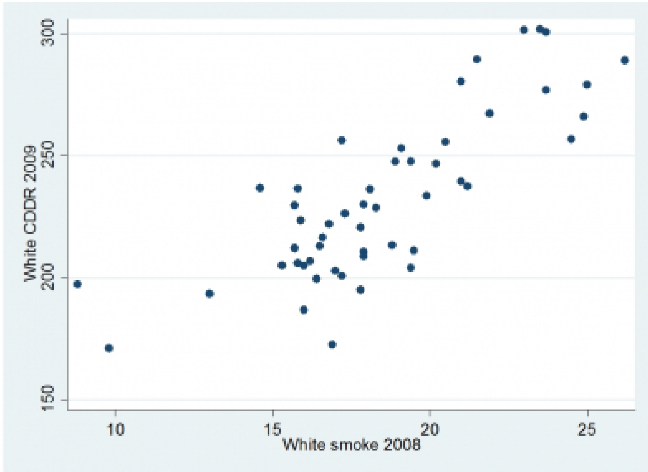

Figure 8

All races smoking and all races CDDR. As smoking rates increase, so too does CDDR.

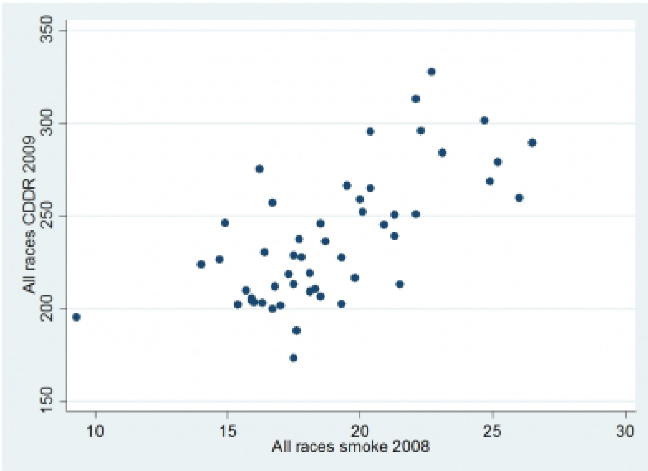

Table 1

Descriptive and summary statistics. GCC = geographic concentration of chiropractors in 2008. GCM = geographic concentration of medical doctors in 2008. GCO = geographic concentration of osteopaths in 2008. WC = white circulator disease death rates (CDDR) in 2009. AC = all races CDDR in 2009. WS = percent of adults who were smokers in 2008. AS = percent of adults, all races who were smokers in 2008. SD = standard deviation.

State	GCC	GCM	GCO	WC	AC	WS	AS
Alabama	1.8	17.2	0.7	301.4	312.8	23.0	22.1
Alaska	3.5	20.4	2.0	195.0	212.9	17.8	21.5
Arizona	3.8	16.9	2.2	204.8	204.2	16.0	15.9
Arkansas	2.0	16.4	0.8	289.3	295.6	21.5	22.3
California	3.8	21.0	0.8	236.6	223.7	14.6	14.0
Colorado	5.0	20.9	1.8	186.7	188.0	16.0	17.6
Connecticut	2.9	26.6	0.9	205.0	205.5	15.3	15.9
Delaware	3.8	20.8	2.5	229.9	237.3	17.9	17.7
Dist of Col	1.2	62.9	1.2	170.9	275.2	9.8	16.2
Florida	2.6	20.8	1.9	211.0	213.1	19.5	17.5
Georgia	3.2	17.4	0.7	255.5	266.2	20.5	19.5
Hawaii	3.8	25.5	1.2	193.4	202.1	13.0	15.4
Idaho	3.5	15.6	1.5	212.9	211.7	16.5	16.8
Illinois	3.0	20.1	1.3	233.4	238.9	19.9	21.3
Indiana	1.7	18.1	1.2	256.6	259.6	24.5	26.0
Iowa	5.1	14.7	3.3	236.2	236.1	18.1	18.7
Kansas	2.8	17.0	1.9	226.2	227.5	17.3	17.8
Kentucky	2.0	18.3	0.8	279.1	279.0	25.0	25.2
Louisiana	1.3	20.0	0.2	280.4	295.3	21.0	20.4
Maine	2.8	23.0	3.9	208.6	209.1	17.9	18.1
Maryland	1.4	27.7	0.8	236.4	246.0	15.8	14.9
Massachusetts	3.1	30.9	0.7	206.7	203.2	16.2	16.0
Michigan	2.9	17.9	4.2	253.0	264.7	19.1	20.4
Minnesota	4.9	22.2	0.7	172.4	173.1	16.9	17.5
Mississippi	1.1	15.0	0.9	301.7	327.5	23.5	22.7
Missouri	3.7	18.0	2.8	266.0	268.6	24.9	24.9
Montana	3.8	20.4	1.3	200.6	206.2	17.2	18.5
Nebraska	2.8	18.3	0.8	210.6	210.6	17.9	18.3
Nevada	2.3	16.3	1.6	267.2	250.6	21.9	22.1
New Hampshire	3.4	23.5	1.7	202.6	201.5	17.0	17.0
New Jersey	3.9	22.9	2.6	229.5	226.2	15.7	14.7
New Mexico	2.6	18.6	1.1	204.0	202.3	19.4	19.3
New York	3.0	26.9	1.2	256.1	257.1	17.2	16.7
North Carolina	2.1	19.5	0.7	237.3	245.2	21.2	20.9
North Dakota	4.5	20.5	0.8	216.4	219.0	16.6	18.1
Ohio	2.0	19.3	2.6	247.4	252.0	18.9	20.1
Oklahoma	2.1	14.0	3.7	300.7	301.3	23.7	24.7
Oregon	3.6	22.4	1.3	205.9	202.9	15.8	16.3
Pennsylvania	3.1	21.2	3.6	246.7	250.5	20.2	21.3
Rhode Island	2.5	25.7	1.6	220.6	218.4	17.8	17.3
South Carolina	3.2	18.6	0.8	239.4	258.7	21.0	20.0
South Dakota	4.2	19.1	1.0	223.3	228.5	15.9	17.5
Tennessee	1.8	20.3	0.8	276.8	284.0	23.7	23.1
Texas	1.9	16.4	1.2	247.6	245.8	19.4	18.5
Utah	3.0	15.8	0.9	197.2	195.2	8.8	9.3
Vermont	3.6	26.3	0.8	199.4	199.7	16.4	16.7
Virginia	1.5	21.1	0.8	221.8	230.2	16.8	16.4
Washington	3.5	21.6	1.1	212.0	209.7	15.7	15.7
West Virginia	1.8	17.9	3.0	289.1	289.3	26.2	26.5
Wisconsin	3.9	20.8	1.2	213.2	216.5	18.8	19.8
Wyoming	3.8	16.9	1.2	228.6	227.3	18.3	19.3
Mean	2.9	21.0	1.5	232.2	237.4	18.5	18.9
SD	1.0	7.0	1.0	33.5	35.3	3.6	3.4
Minimum	1.1	14.0	0.2	170.9	173.1	8.8	9.3
Maximum	5.1	62.9	4.2	301.7	327.5	26.2	26.5

Table 2

Pearson correlations (r) and corresponding p-value (p) between the circulatory disease death rates (CDDR) in 2009 and the other variables. GCC – geographic concentrations of chiropractors in 2008. GCM - geographic concentrations of medical doctors in 2008. GCO - geographic concentrations of osteopaths in 2008. Smoking = percent of adults who were smokers in 2008.

		White CDDR		All races CDDR	
Variable	n	r	p	r	p
GCC	51	-0.541	<0.0001	-0.670	<0.0001
GCM	51	-0.447	0.0010	-0.092	0.5219
GCM w/o outlier	50	-0.447	0.0011	-0.435	0.0016
GCO	51	0.111	0.4364	0.065	0.6502
Smoking	51	0.798	<0.0001	0.674	<0.0001

Table 3

Linear multiple regression and semi-partial correlation squared findings for circulatory disease death rates (CDDR) in 2009 versus predictors that were statistically significant in correlation analysis. RC = regression coefficient. SPC2 = semi-partial correlation squared value. (p) = p-value associated with adjacent coefficient. GCC = geographic concentration of chiropractors in 2008. GCM = geographic concentrations of medical doctors in 2008. Smoking = percent of adults who were smokers in 2008.

Predictor	n	RC (p)	SPC^2 (p)
	Whites (R-squared = 0.734, p<0.0001)		
Smoking	51	5.1 (<0.001)	0.16 (<0.0001)
GCC	51	-12.2 (<0.001)	0.10 (0.0002)
GCM	51	-1.1 (0.001)	0.03 (0.0196)
	All races (without GCM outlier; R-squared = 0.690 (p<0.0001)		
GCC	50	-16.3 (<0.001)	0.17 (<0.0001)
Smoking	50	4.6 (<0.001)	0.13 (0.0001)
GCM	50	-1.8 (0.025)	0.03 (0.0476)

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Author Information

John Hart, DC, MHSc
Greenville, South Carolina
jhartdc@yahoo.com