

Link between prostate cancer diagnosis and stroke in the United States during 2007–2017

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Abstract

Introduction: The main purpose of this work is to study prostate cancer and stroke in the United States during the years 2007–2017 and to find not only statistically significant predictors for cancer, but also a possible association between prostate cancer and stroke.

Material and methods: The statistical methods used to derive the results of this work are χ^2 test and one-way analysis of variance (ANOVA), in order to check the statistical significance of prostate cancer in relation to socio-economic factors of patients. In addition, a multivariate logistic regression analysis was used with the odds ratio (OR) to find statistically significant prognostic factors for both prostate cancer and stroke.

Results: According to multiple logistic regression analysis, males who are unemployed but have worked previously have 16 times higher risk of developing prostate cancer, while widowed men have five times higher risk for the occurrence of this type of cancer. In addition, marital status and employment proved to be also prognostic risk factors for stroke.

Conclusions: Our results describe for the first time the importance of deprivation (of work and partner) as a primary prognostic risk factor for cancer. Moreover, the same factor proved to be the primary prognostic risk factor for stroke as well as for prostate cancer, a fact that implies a possible link between cancer and stroke.

Key words: prognostic factors, prostate cancer, stroke, socio-economic factors.

Introduction

The incidence of cancer is rapidly growing worldwide. This is due to both the aging and growth of the population, as well as changes in the prevalence of the main risk factors for cancer, several of which are associated with socioeconomic development [1, 2]. Prostate cancer ranks not only as the second most frequently diagnosed cancer, but also the fifth leading cause of cancer death in men, with an estimated 1.3 million new cases and 359,000 deaths worldwide in 2018 [3].

Little is known about prostate cancer aetiology, while important risk factors are age, race, positive family history of prostate cancer, and diet [4]. More specifically, 66 years considered is the average age of onset of this disease, while African-American is the race with the most frequent incidence of prostate cancer [5, 6]. Low socio-economic status is associated with increased incidence and mortality from cancer [7]. Howev-

er, men with a high socioeconomic status (SES) have a higher incidence of prostate cancer than men with low SES [8–13]. This is probably due to different behaviour in the search for medical care [9, 10, 14–16]. However, prostate cancer mortality is not similar, and prostate cancer survival is poorer in men with lower SES [17–19]. Men with low SES may have a lower level of literacy and health awareness and may perceive cancer screening as more threatening, more difficult, and less beneficial [20]. In order to reduce cancer-preventable deaths, it is therefore important to examine factors related to non-attendance in prostate screening.

Prior studies have found increased risk of stroke in patients with cancer. More specifically, it has been found, according to autopsy data, that 15% of patients diagnosed with cancer have pathological evidence of cerebrovascular disease upon death [21], and several studies have demonstrated that stroke is common in patients with cancer [22–24]. The underlying mechanisms of stroke are related to cancer-mediated hypercoagulability or complications of oncological treatments [21, 22, 25, 26].

This work studies prostate cancer and stroke in the United States in the years 2007–2017 in order to find statistically significant predictors of cancer and a possible link between prostate cancer and stroke.

Material and methods

The data used in this work come from the National Health Interview Survey (NHIS) dataset [27] and cover the period 2007–2017. The target population for the NHIS is the civilian noninstitutionalized population of the United States. NHIS data are collected through personal household interviews. The main objective of the NHIS is to monitor the health of the U.S. population through the collection and analysis of data on a broad range of health topics. The number of adult patients with prostate cancer examined was 26,591.

Moreover, in the geographic classification of the U.S. population, states are grouped into four regions used by the U.S. Census Bureau:

- Northeast: Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.
- Midwest: Ohio, Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Kansas, and Nebraska.
- South: Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Oklahoma, Arkansas, and Texas.
- West: Washington, Oregon, California, Nevada, New Mexico, Arizona, Idaho, Utah, Colorado, Montana, Wyoming, Alaska, and Hawaii.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statistical analysis

The statistical methods used to extract the results of this work are the χ^2 test for categorical and one-way analysis of variance (ANOVA) for continuous variables, to check the statistical significance of prostate cancer in relation to socio-economic characteristics of patients, such as age, race, origin, education, family income, poverty status, health insurance coverage, place of residence, and region. Factors that determine the prevalence of cancer were assessed by using multiple logistic regression analysis. To assess the predictors of cancer, we used data in patients with a new diagnosis of cancer compared to a matched cohort of patients without cancer. More specifically, the control group consisted of target population without cancer with the same socioeconomic characteristics as the patient group. The data were weighted before being analysed. Predictors were represented using the OR and 95% confidence intervals, and $p < 0.05$ was considered as statistically significant. The study was carried out using the IBMSPSS 25 software package for Windows.

Results

To check the zero hypothesis that the mean of the patients in the United States with prostate cancer did not differ according to their socio-economic characteristics, the χ^2 test and One-way analysis of variance (ANOVA) were used. As shown in Table I, there was a statistically significant difference in the number of malignant neoplasms of the prostate in relation to age, and this occurred mainly in the age group of 75 years and over (41.5%), while the most common origin and race was Black or African American (70.4%), not Hispanic or Latino (48.7%). The education that was found to be statistically significant was “bachelor’s degree or higher” (36.3%). The employment status which was seen to be statistically significant was “not employed but has worked previously” (57%). The poverty status that was seen to be statistically significant was “not poor” (80.3%), with a family income of \$35,000 or more (40.9%). The health insurance coverage that was statistically significant in both age groups (under 65 years (81.4%) and 65 years and over (58.8%)) was private. In addition, the majority of prostate cancer patients had “married” marital status (72.9%).

Table I. Socio-economic characteristics of prostate cancer patients: United States 2007–2017 (χ^2 and one-way ANOVA test)

Characteristics	Number of patients	Percentages	P-value
Gender:			< 0.001
Male	26,591	100	
Female	0	0	
Age:			< 0.001
18–44	10	0.0	
45–64	5,790	21.8	
65–74	9,736	36.7	
75 and over	11,008	41.5	
Race:			0.001
White	3,932	19.7	
Black or African American	14,032	70.4	
Asian	1,971	9.9	
Origin:			< 0.001
Hispanic or Latino	1,554	3.0	
Mexican or Mexican American	753	1.5	
Not Hispanic or Latino	25,037	48.7	
White, single race	20,770	40.4	
Black or African American, single race	3,329	6.5	
Education:			< 0.001
Less than a high school diploma	3,841	14.5	
High school diploma	6,678	25.3	
Some college	6,317	23.9	
Bachelor's degree or higher	9,611	36.3	
Employment:			< 0.001
Employed:	4,175	21.5	
Full-time		15.3	
Part-time		5.6	
Unemployed but has worked previously	11,093	57	
Unemployed and has never worked	114	0.6	
Family income:			< 0.001
Less than \$35,000	7,317	18.3	
\$35,000 or more	16,382	40.9	
\$35,000–\$49,999	3,665	9.1	
\$50,000–\$74,999	4,518	11.3	
\$75,000–\$99,999	2,771	6.9	
\$100,000 or more	5,426	13.5	
Poverty status:			< 0.001
Poor	1,261	5.2	
Near poor	3,473	14.5	
Not poor	19,291	80.3	
Health insurance coverage:			< 0.001
Under 65:			
Private	4,525	81.4	
Medicaid	313	5.6	
Other coverage	620	11.2	
Uninsured	102	1.8	

Table I. Cont.

Characteristics	Number of patients	Percentages	P-value
65 and over:			< 0.001
Private	11,126	58.8	
Medicare and Medicaid	676	3.6	
Medicare only	5,005	26.4	
Other coverage	2,119	11.2	
Marital status:			< 0.001
Married	19,340	72.9	
Widowed	2,882	10.9	
Divorced or separated	2,583	9.7	
Never married	1,069	4.0	
Living with a partner	651	2.5	
Place of residence:			< 0.001
MSA (Metropolitan statistical area):			
Large MSA (population size 1 million or more)	13,001	48.9	
Small MSA (less than 1 million)	8,788	33.1	
Not in MSA	4,800	18.1	
Region:			< 0.001
Northeast	5,101	19.2	
Midwest	6,092	22.9	
South	10,061	37.8	
West	5,337	20.1	

Finally, the region with the most frequent occurrence of prostate cancer was south (37.8%), with a population size of one million or more (48.9%).

Table II shows the multiple logistic regression analysis and odds ratios in order to find predictors for the occurrence of prostate cancer.

As shown in Table II, all prognostic factors are statistically significant ($p < 0.05$). According to multiple logistic regression, the risk of prostate cancer is significantly higher in the age group of 75 years and over (OR = 1.0), Black or African American race (OR = 3.1), and “bachelor’s degree or higher” education status (OR = 1.0). Moreover, those who were not employed but have worked previously have 16 times the risk of developing prostate cancer (OR = 16.7). In addition, the risk of cancer is significantly higher with family income \$35,000–\$49,999 (OR = 1.2), poverty status “not poor” (OR = 1.0), health insurance coverage “other coverage” in both age groups – under 65 years and 65 years and over (OR = 24.0 and OR = 1.0, respectively). Widowed men have higher risk of developing prostate cancer (OR = 5.4). Finally, the risk of prostate cancer is significantly higher for region “Northeast” (OR = 1.2) and place of residence “not in metropolitan statistical area” (OR = 1.0).

Figure 1 shows the trends in prostate cancer and stroke during the years 2007–2017 in the

United States. The incidence of prostate cancer and stroke continued to increase from 2007 to 2017.

In order to find a possible link between prostate cancer and stroke, a multivariate logistic regression analysis was also used for stroke patients. As can be seen from Table III, marital status plays a crucial role in the incidence of stroke. Widowed adults have the highest risk for the occurrence of stroke (OR = 6.0). Family income and education are also prognostic risks for stroke. More specifically, family income “less than \$35,000” (OR = 4.0) and “less than a high school diploma” education status (OR = 3.7) have four times higher risk for stroke. Finally, adults who were unemployed but had worked previously had two times the risk of stroke (OR = 1.9). Moreover, the risk of stroke was significantly higher with female gender (OR = 1.0), age over 75 years (OR = 1.0), and Black or African American race (OR = 2.4). The risk of stroke is significantly higher with poverty status “near poor” (OR = 2.0), health insurance coverage “other coverage” under 65 years old and “Medicare and Medicaid” over 65 years old (OR = 5.6 and OR = 1.3, respectively). Finally, the risk of stroke is significantly higher with region “south” (OR = 1.32) and place of residence “not in metropolitan statistical area” (OR = 1.0).

Table II. Socio-economic characteristics of prostate cancer patients: United States 2007–2017. Statistically significant predictors of prostate cancer in the US using multivariate logistic regression

Characteristics	Patients	Controls	Odds ratio (95% CI)	P-value
Age:				< 0.001
18–44	10	1,227,959	0.0 (0.9–1.0)	
45–64	5,790	885,288	0.11 (0.1–0.11)	
65–74	9,736	253,672	0.66 (0.64–0.67)	
75 and over	11,008	189,502	1.0 (ref)	
Race:				< 0.001
White	3,932	2,058,749	0.12 (0.12–0.13)	
Black or African American	14,032	298,208	3.1 (3.1–3.4)	
Asian	1,971	136,693	1.0 (ref)	
Origin:				< 0.001
Hispanic or Latino	1,554	378,228	0.36 (0.34–0.38)	
Mexican or Mexican American	753	232,378	0.28 (0.26–0.31)	
Not Hispanic or Latino	25,037	2,178,145	1.0 (0.9–1.0)	
White single race	20,770	1,697,611	1.1 (1.0–1.1)	
Black or African American, single race	3,329	296,303	1.0 (ref)	
Education:				< 0.001
Less than a high school diploma	3,841	301,130	0.93 (0.9–0.97)	
High school diploma	6,678	574,687	0.85 (0.82–0.88)	
Some college	6,317	635,644	0.73 (0.7–0.75)	
Bachelor's degree or higher	9,611	705,943	1.0 (ref)	
Employment:				< 0.001
Employed	4,175	882,819	3.3 (2.7–4.0)	
Full-time	2,975	714,405	2.9 (2.4–3.5)	
Part-time	1,092	155,759	4.9 (4.0–6.0)	
Unemployed but has worked previously	11,093	466,614	16.7 (13.9–20.1)	
Unemployed and has never worked	114	80,472	1.0 (ref)	
Family income:				< 0.001
Less than \$35,000	7,317	761,703	0.98 (0.94–1.0)	
\$35,000 or more	16,382	1,580,026	1.05 (1.02–1.1)	
\$35,000–\$49,999	3,665	317,008	1.2 (1.1–1.2)	
\$50,000–\$74,999	4,518	418,634	1.1 (1.0–1.1)	
\$75,000–\$99,999	2,771	290,967	0.97 (0.92–1.0)	
\$100,000 or more	5,426	553,418	1.0 (ref)	
Poverty status:				< 0.001
Poor	1,261	306,723	0.35 (0.33–0.37)	
Near poor	3,473	410,500	0.7 (0.6–0.7)	
Not poor	19,291	1,640,643	1.0 (ref)	
Health insurance coverage:				< 0.001
Under 65:				
Private	4,525	1,408,435	11.8 (9.7–14.4)	
Medicaid	313	225,581	5.1 (4.0–6.3)	
Other coverage	620	92,450	24.0 (20.0–30.4)	
Uninsured	102	376,093	1.0 (ref)	

Table II. Cont.

Characteristics	Patients	Controls	Odds ratio (95% CI)	P-value
65 and over:				< 0.001
Private	11,126	219,629	0.68 (0.64–0.7)	
Medicare and Medicaid	676	30,512	0.3 (0.2–0.3)	
Medicare only	5,005	109,963	0.6 (0.5–0.6)	
Other coverage	2,119	28,472	1.0 (ref)	
Marital status:				< 0.001
Married	19,340	1,364,442	4.0 (3.7–4.3)	
Widowed	2,882	151,892	5.4 (4.9–5.8)	
Divorced or separated	2,583	289,072	2.5 (2.3–1.7)	
Never married	1,069	561,390	0.5 (0.4–0.6)	
Living with a partner	651	185,228	1.0 (ref)	
Place of residence:				< 0.001
MSA (Metropolitan statistical area):				
Large MSA (population size 1 million or more)	13,001	1,370,291	0.77 (0.74–0.8)	
Small MSA (less than 1 million)	8,788	794,289	0.9 (0.8–0.9)	
Not in MSA	4,800	391,797	1.0 (ref)	
Region:				< 0.001
Northeast	5,101	451,765	1.24 (1.1–1.3)	
Midwest	6,092	588,515	1.14 (1.1–1.2)	
South	10,061	927,851	1.19 (1.15–1.23)	
West	5,337	588,242	1.0 (ref)	

Discussion

Increasing attention should be given to the prognostic factors that had the highest odds ratio. It is noted that the socio-economic characteristic of cancer patients with the highest risk is health insurance coverage, and more specifically it was found that men with “other coverage” had the highest risk of developing prostate cancer (OR = 24.0). Moreover, employment status plays a crucial role in developing this type of cancer. Men

who were unemployed but had worked previously had a 16-fold increased risk of developing prostate cancer (OR = 16.7). Finally, marital status is a prognostic risk for this type of cancer, as widowed men were found to have a five-fold higher risk of developing prostate cancer (OR = 5.4).

It is also noteworthy that the socio-economic characteristics of stroke patients with the highest odds ratio were the same as those of prostate cancer patients. Deprivation of work and partner proved to be the primary prognostic risk factor for both stroke and prostate cancer, a fact that implies a possible link between cancer and stroke.

The importance of this study lies in the association of multiple socio-economic variables with cancer and stroke, which reflects the complexity and multidimensional nature of deprivation as well as the various roles of these dimensions during the course of life, which in turn reflects the longest gestation period for both cancer and stroke. More specifically, we found that partner and work deprivation, two determinants in the life of an adult, rapidly increase the risk of cancer as well as stroke. We also found that not only deprivation but also the death of a partner plays a key role in the increased risk of developing these two diseases.

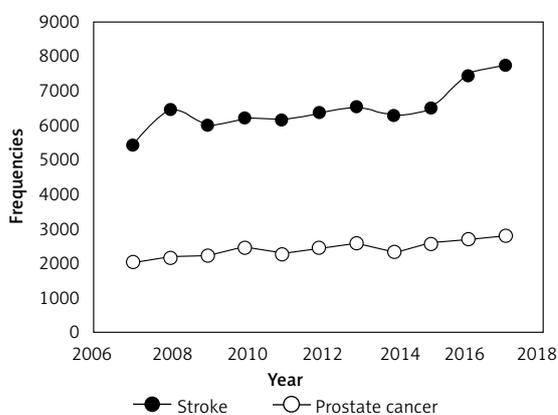


Figure 1. Trends in prostate cancer and stroke during the years 2007–2017 in the United States

Table III. Characteristics of stroke patients: United States 2007–2017. Statistically significant predictors of Stroke in the US using multivariate logistic regression

Characteristics	Patients	Controls	Odds ratio (95% CI)	P-value
Gender:				< 0.001
Male	33,439	1,212,966	0.94 (0.93–0.96)	
Female	37,788	2,512,279	1.0 (ref)	
Age:				< 0.001
18–44	6,670	1,221,299	0.0 (0.04–0.05)	
45–64	25,876	865,202	0.26 (0.25–0.26)	
65–74	16,350	247,058	0.57 (0.56–0.58)	
75 and over	20,650	179,860	1.0 (ref)	
Race:				< 0.001
White	55,820	2,006,861	1.8 (1.7–1.9)	
Black or African American	11,216	301,024	2.4 (2.3–2.5)	
Asian	2,059	136,605	1.0 (ref)	
Origin:				< 0.001
Hispanic or Latino	7,046	372,736	0.49 (0.48–0.5)	
Mexican or Mexican American	4,141	228,990	0.47 (0.45–0.49)	
Not Hispanic or Latino	64,183	2,138,999	0.78 (0.77–0.8)	
White single race	49,431	1,668,950	0.77 (0.76–0.79)	
Black or African American. single race	10,980	288,652	1.0 (ref)	
Education:				< 0.001
Less than a high school diploma	17,321	287,650	3.7 (3.6–3.8)	
High school diploma	21,698	559,667	2.4 (2.3–2.5)	
Some college	18,229	623,732	1.8 (1.7–1.9)	
Bachelor's degree or higher	11,281	704,273	1.0 (ref)	
Employment:				< 0.001
Employed:	8,092	878,902	0.26 (0.25–0.27)	
Full-time	5,809	711,571	0.23 (0.22–0.24)	
Part-time	2,048	154,803	0.38 (0.36–0.4)	
Unemployed but has worked previously	30,099	447,608	1.9 (1.8–2.0)	
Unemployed and has never worked	2,703	77,883	1.0 (ref)	
Family income:				< 0.001
Less than \$35,000	35,167	733,853	4.0 (3.9–4.1)	
\$35,000 or more	29,159	1,567,249	1.58 (1.54–1.6)	
\$35,000–\$49,999	9,434	311,239	2.6 (2.5–2.7)	
\$50,000–\$74,999	8,885	414,267	1.8 (1.7–1.9)	
\$75,000–\$99,999	4,352	289,386	1.28 (1.23–1.33)	
\$100,000 or more	6,487	552,357	1.0 (ref)	
Poverty status:				< 0.001
Poor	11,412	296,572	1.84 (1.8–1.88)	
Near poor	17,036	396,937	2.0 (2.0–2.1)	
Not poor	33,938	1,625,996	1.0 (ref)	

Table II. Cont.

Characteristics	Patients	Controls	Odds ratio (95% CI)	P-value
Health insurance coverage:				< 0.001
Under 65:				
Private	13,674	1,399,286	0.9 (0.8–0.9)	
Medicaid	9,113	216,781	3.7 (3.6–3.9)	
Other coverage	5,522	87,548	5.6 (5.4–5.9)	
Uninsured	4,132	372,063	1.0 (ref)	
65 and over:				0.000
Private	16,903	213,852	0.62 (0.6–0.65)	
Medicare and Medicaid	4,465	26,723	1.3 (1.2–1.4)	
Medicare only	9,540	105,428	0.7 (0.68–0.74)	
Other coverage	3,427	27,164	1.0 (ref)	
Marital status:				< 0.001
Married	34,946	1,348,836	1.5 (1.4–1.6)	
Widowed	14,517	140,257	6.0 (5.8–6.2)	
Divorced or separated	12,491	279,164	2.6 (2.5–2.7)	
Never married	6,068	556,391	0.6 (0.61–0.66)	
Living with a partner	3,128	182,751	1.0 (ref)	
Place of residence:				< 0.001
MSA (Metropolitan statistical area):				
Large MSA (population size 1 million or more)	32,809	1,350,483	0.61 (0.6–0.62)	
Small MSA (less than 1 million)	21,500	781,577	0.7 (0.67–0.7)	
Not in MSA	15,148	381,449	1.0 (ref)	
Region:				< 0.001
Northeast	10,867	445,999	1.08 (1.05–1.1)	
Midwest	16,569	578,038	1.27 (1.24–1.3)	
South	27,173	910,739	1.32 (1.29–1.35)	
West	13,083	580,496	1.0 (ref)	

In conclusion, this paper has highlighted that different socioeconomic variables are associated with different cancer risks, while deprivation (of work and partner) proved to be the primary prognostic risk factor for cancer. Moreover, the same factor proved to be the primary prognostic risk factor for stroke as well as for prostate cancer, a fact that implies a possible link between cancer and stroke.

Conflict of interest

The authors declare no conflict of interest.

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