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Aging, Disease, and Disparity: Unraveling Links Between Prostate Cancer and Heart Failure

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Intro

Prostate cancer, as highlighted by the Centers for Disease Control and Prevention (CDC), represents a significant health challenge, being a leading cause of cancer death among men of all races. With an incidence rate on the rise since 2014 and projections indicating around 299,010 new cases in 2024 in the United States alone, the need to understand its interplay with other prevalent conditions like congestive heart failure (CHF) is increasingly crucial. CHF itself, a major contributor to global morbidity and mortality, shares common risk factors with prostate cancer, including age, obesity, and smoking. This shared risk profile underscores the importance of examining the potential links between these conditions.

Methods

To investigate the potential association between prostate cancer and congestive heart failure (CHF), we utilized data from the National Health and Nutrition Examination Survey (NHANES), specifically collected between March 2017 and March 2020. This dataset included information on medical conditions relevant to our study. We conducted a logistic regression analysis, adjusting for variables such as age, race, education, and marital status to determine the relationship between a history of prostate cancer and CHF. A logistic regression model was employed using R. Regression results yielded odds ratios, confidence intervals, and p-values for our findings.

Results

Results from the analysis of 13,772 participants indicated that prostate cancer was not significantly associated with an increased risk of CHF, with an odds ratio of 0.8973 ($p=0.74$). However, age was a significant factor, increasing CHF odds by 6.22% for each additional year. Racial disparities were evident, with non-Hispanic whites and Blacks showing higher CHF odds. Educational attainment was inversely correlated with CHF risk, highlighting socioeconomic factors' influence on health outcomes.

Conclusion

In conclusion, our findings suggest no direct comorbidity between prostate cancer and CHF but underscore the significance of age, race, and education in CHF risk. These insights contribute to the broader understanding of CHF risk factors, emphasizing the need for tailored public health strategies and interventions. Future research should continue to explore the intricate relationships between chronic conditions and demographic factors to enhance disease management and prevention strategies.

INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), prostate cancer is a leading cause of cancer death among men of all races.¹ Since 2014, the incidence rate has increased by 3% per year overall and by about 5%

per year for advanced-stage prostate cancer. The American Cancer Society estimates approximately 299,010 new cases in 2024, leading to about 35,250 deaths in the United States alone.² The lifetime risk for developing prostate cancer is approximately 12.9 percent for men and an estimated 3,343,976 men were living with prostate cancer in the United States in 2020.³ Such statistics reveal not only the

widespread nature of this disease but also the critical importance of understanding its relationship with other disease states.

Another significant public health concern is congestive heart failure (CHF) a term often used synonymously with heart failure (HF). Despite the terminological variance, HF includes conditions like CHF and is a significant contributor to global morbidity and mortality. HF has a global burden consisting of a prevalence of 1-3% in the general adult population, an incidence of 1-20 cases per 1000 population, and 5-year mortality of 50-75%.⁴ The prevalence of HF in the United States stands at about 6.2 million adults. In 2018, heart failure was mentioned on 379,800 death certificates (13.4%).⁵ The economic burden due to Heart failure is estimated at \$30.7 billion.⁶ The prevalence and incidence rates, along with the high mortality rate associated with HF, suggest that CHF, as a subset of heart failure, likely shares a similar burden. Indeed, CHF is a common disorder worldwide with a high morbidity and mortality rate. With an estimated prevalence of 26 million people worldwide.⁷

HF and prostate cancer share several risk factors, including smoking, obesity, and non-modifiable factors such as age.⁸ Some studies suggest that patients with heart failure have a higher likelihood of developing cancer, possibly due to inflammation and oxidative stress.^{10,11} However, there is conflicting evidence on whether HF is associated with cancer. Other studies show no such relationship between HF and cancer¹² or specifically no association of HF with reduced ejection fraction with total cancer.¹³ More specifically studies have shown that while there may be an association between HF and cancer such association was not found in prostate cancer.^{12,14,15}

Given the mixed findings from various studies on the relationship between heart failure, and prostate cancer, our study aims to bring clarity to this issue by leveraging data from the National Health and Nutrition Examination Survey (NHANES). NHANES provides a wealth of cross-sectional data encompassing both clinical and self-reported health information from a diverse, nationally representative sample. This rich dataset allows for an in-depth examination of the potential correlations between prostate cancer and heart failure, specifically congestive heart failure. By tapping into NHANES, we hope to elucidate the complex interplay between these two conditions, which could potentially inform future screening and management practices.

MATERIALS AND METHODS

DATA COLLECTION

The research utilized data from the National Health and Nutrition Examination Survey (NHANES), managed by the CDC. This data, collected between March 2017 and March 2020, included questionnaire responses specifically from the “medical conditions” section including information on congestive heart failure and prostate cancer.

VARIABLES

The inclusion criteria for this study were based on prostate cancer status and history of CHF. Prostate cancer history was evaluated by an answer of “yes” in response to the survey question “Have you ever been told you had cancer or malignancy?” and indicating “prostate” as the response to the subsequent query “What kind was it?” The dependent variable was the history of congestive heart failure. This was established as an answer of “yes” in response to the survey question “Has a doctor or other health professional ever told you that you had congestive heart failure?”. Those who answered No to the questions regarding malignancy or CHF, or answered Yes to having a malignancy but stated a cancer other than prostate were excluded. To account for influential variables, other factors such as age, race, educational status, and marital status were identified as well. The independent variable of interest was the historical occurrence of prostate cancer while the dependent variable was a history of congestive heart failure.

STATISTICAL ANALYSIS

R was utilized to merge and analyze data from the NHANES database. Data cleaning and restructuring, including the recoding of variables like CHF status, Prostate Cancer Status, race, education, and marital status was done. Descriptive statistics were generated to summarize the characteristics of the study population, including the mean age of participants, racial distribution, education levels, and marital status stratified by prostate cancer history. The analysis culminated in fitting a logistic regression model to explore the associations between CHF status and various predictors, providing insights into the likelihood of CHF occurrence relative to demographic and health-related variables. The results, including odds ratios, confidence intervals, and p-values, were summarized to identify significant predictors within the study population. The level of significance was set at $p < 0.05$. All statistical analyses were conducted using R version 4.2.0 (Released 2023; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Analysis of the NHANES dataset yielded a result of 138 participants with prostate cancer and 13,634 without a history of prostate cancer. Those with a history of prostate cancer had a median age of 72.3 years, significantly higher than the median age of 34.7 years in the non-cancer group. CHF was more common in the prostate cancer group, affecting 7.97% compared to only 2.30% in the control group. In terms of racial distribution, most of the prostate cancer group identified as black or white. 53.62% of the prostate cancer patients were white, and 32.61% of the prostate cancer group was black. Regarding education, the distribution was varied. Individuals with prostate cancer were more likely to have some college education or an associate degree (31.6%) or to be college graduates (28.26%) than those

Table 1. Demographic characteristics

Variable	History of prostate cancer N (%)	No history of prostate cancer N (%)
Total	138	13634
Age (Median in years)	72.3	34.7
CHF	11 (7.97)	313 (2.30)
Race		
Mexican American	3 (2.17)	1760 (12.91)
Other Hispanic	8 (5.80)	1365 (10.01)
White	74 (53.62)	4491 (32.94)
Black	45 (32.61)	3643 (26.72)
Multi-Racial	8 (5.80)	2375 (17.42)
Education level		
Less than 9th grade	6 (4.35)	660 (4.84)
9-11th grade	12 (8.70)	935 (6.86)
High school graduate/GED or equivalent	37 (26.81)	2023 (14.84)
Some college/AA degree	43 (31.6)	2728 (20.01)
College graduate or above	39 (28.26)	2048 (15.02)
Marital status		
Married	86 (62.32)	4833 (35.45)
Widowed/divorced/separated	46 (33.33)	1905 (13.97)
Never married	6 (4.35)	1660 (12.18)

CHF - Congestive Heart Failure; GED - General Educational Development; AA - Associate of Arts

without prostate cancer. As far as marital status 62.32% of prostate cancer patients were married (Table 1).

The logistic regression analysis showed having prostate cancer was not significantly associated with the odds of having CHF, indicated by an odds ratio of 0.8973 and a p-value of 0.740683. Age, however, was significantly associated with an increase in odds by 6.22% for each additional year ($p < 0.0001$), suggesting a strong age-related effect as expected.

Non-Hispanic Whites and Non-Hispanic Blacks had significantly higher odds of CHF with an odds ratio of 2.3315 ($p = 0.003877$) and 2.7843 ($p = 0.000513$), respectively. Educational attainment appeared to be inversely associated with the outcome. Those who were college graduates were found to have a significant reduction in odds of having CHF (OR = 0.2973, $p = < 0.0001$) (Table 2).

DISCUSSION

Our study, leveraging data from NHANES, has provided a comprehensive examination of the potential link between prostate cancer and congestive heart failure (CHF). Despite the initial hypothesis suggesting a possible association, our results indicated no significant correlation between prostate cancer and the likelihood of developing CHF. This finding aligns with segments of existing literature that refute a direct relationship between heart failure and specific cancers, including prostate cancer.

One of the standout results from our analysis was the significant role of age as a predictor for CHF. The logistic

regression model showed a 6.22% increase in the odds of CHF for each additional year of age. This outcome is consistent with well-established cardiovascular research, which identifies advancing age as a major risk factor for heart failure [16]. As individuals age, cumulative exposure to various risk factors, along with physiological changes in the cardiovascular system, likely contributes to the increased prevalence of CHF among older populations. This finding reinforces the critical need for age-specific strategies in managing and preventing heart failure.

Another critical aspect of our results is the evident racial disparities in CHF prevalence. Our analysis revealed that Non-Hispanic Whites and Non-Hispanic Blacks had significantly higher odds of having CHF compared to other racial groups. Specifically, Non-Hispanic Blacks had the highest odds ratio, underscoring a significant health disparity. This observation resonates with existing studies that have documented racial and ethnic disparities in heart failure incidence and outcomes.¹⁶ The heightened odds among Non-Hispanic Blacks may be attributed to a combination of genetic factors, socioeconomic challenges, and disparities in healthcare access and quality. Addressing these disparities is crucial for improving heart failure outcomes and achieving health equity.¹⁷

The study also highlighted an intriguing inverse relationship between educational attainment and CHF. Participants with higher educational levels, particularly college graduates, exhibited significantly lower odds of developing CHF. This protective effect of education could be due to several factors. Higher educational attainment often corre-

Table 2. Correlation coefficients of variables and Congestive Heart Failure

Variable	Coefficient	Odds Ratio	p-value	Lower CI Odds Ratio	Upper CI Odds Ratio
Prostate Cancer	-0.1084	0.8973	0.740683	0.472	1.705
Age	0.06031	1.0622	<0.0001***	1.052	1.072
Other Hispanic	0.506	1.6586	0.13072	0.861	3.197
Non-Hispanic White	0.8465	2.3315	0.003877	1.313	4.141
Non-Hispanic Black	1.024	2.7843	0.000513***	1.562	4.962
Multi-Racial	0.5674	1.7637	0.082945	0.929	3.35
9-11th grade	-0.02998	0.9705	0.903164	0.599	1.573
High school graduate/ GED	-0.07386	0.9288	0.743937	0.596	1.447
Some college or AA degree	-0.2289	0.7954	0.310743	0.511	1.238
College graduate or above	-1.213	0.2973	<0.0001***	0.174	0.507
Married	0.1705	1.1859	0.18206	0.923	1.523
Never married	0.1972	1.218	0.338703	0.813	1.824

GED - General Educational Development; AA - Associate of Arts; CI: confidence interval

The level of significance was set at $p < 0.05$

***: $p < 0.001$ (highly significant)

lates with better socioeconomic status, healthier lifestyle choices, improved health literacy, and greater access to healthcare resources. These factors collectively contribute to a reduced risk of chronic conditions, including CHF.¹⁸ This finding emphasizes the importance of promoting educational opportunities as a long-term strategy for improving public health.

Our results must be considered in the context of other research on this topic. For instance, previous studies have shown mixed results regarding the relationship between heart failure and cancer. Some studies suggest a higher likelihood of developing cancer among heart failure patients, possibly due to shared risk factors like chronic inflammation and oxidative stress.^{10,11} However, other studies, including ours, have found no significant association, particularly with specific cancers like prostate cancer.¹²⁻¹⁵ This discrepancy highlights the complexity of the relationship between heart failure and cancer and suggests that the interplay of these conditions may vary depending on the type of cancer and individual patient factors.

Furthermore, our findings on the protective role of education align with broader research demonstrating the impact of socioeconomic factors on health outcomes. Socioeconomic status, encompassing education, income, and occupation, significantly influences health behaviors, access to healthcare, and overall well-being. Higher socioeconomic status is often associated with better health outcomes, including a lower risk of chronic diseases like heart failure. These insights underscore the multifaceted nature of health determinants and the need for holistic approaches in public health interventions.

LIMITATIONS

This study has several limitations. The cross-sectional design of the NHANES data restricts our ability to establish causality between prostate cancer and congestive heart failure (CHF). Self-reported data may introduce recall bias, affecting the accuracy of prostate cancer and CHF histories. The relatively small sample size of prostate cancer cases ($n=138$) limits the generalizability and statistical power of our findings. Additionally, despite adjusting for multiple covariates, residual confounding from unmeasured variables such as lifestyle factors and genetic predispositions may still be present. Future research using longitudinal data and more detailed clinical information is needed to better understand the relationship between these conditions.

CONCLUSIONS

Our study, utilizing data from the NHANES, aimed to explore the relationship between prostate cancer and CHF. The analysis revealed no significant association between a history of prostate cancer and the odds of developing CHF. However, our findings underscored the significant impact of age and racial disparities on CHF prevalence. Specifically, the odds of CHF increased with advancing age, and Non-Hispanic Whites and Non-Hispanic Blacks exhibited higher odds of CHF compared to other racial groups. Additionally, educational attainment was found to be inversely associated with CHF, suggesting that higher education levels may offer a protective effect against this condition.

While our study provides important insights, it also highlights the complexity of the interplay between chronic diseases and the influence of socio-demographic factors. The lack of a significant association between prostate can-

cer and CHF aligns with some existing literature but contrasts with studies suggesting a broader link between heart failure and cancer. These discrepancies emphasize the need for further research, particularly longitudinal studies, to elucidate the potential mechanisms underlying these relationships. Addressing the identified disparities and enhancing educational opportunities could be key strategies for mitigating the burden of CHF and improving public

health outcomes. Future studies should incorporate more comprehensive clinical data and consider additional confounding factors to provide a more nuanced understanding of these complex interactions.

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