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Original Article

Obesity, age, ethnicity, and clinical features of prostate cancer patients

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Abstract: Approximately 36.5% of the U.S. adults (≥ 20 years old) are obese. Obesity has been associated with type 2 diabetes mellitus, cardiovascular disease, stroke, and several types of cancer. The present study included 1788 prostate cancer patients who were treated with radical prostatectomy at the Ochsner Health System, New Orleans, Louisiana, from January, 2001 to March, 2016. The patient's medical records were retrospectively reviewed. Body mass index (BMI), age, ethnicity (Caucasians versus African Americans), clinical stage, Gleason score, and prostate-specific antigen (PSA) levels were retrieved. The relative risk of the patients was stratified into low risk and high risk groups. Associative analyses found that BMI was associated with age, clinical stage, Gleason score, but not ethnicity, PSA levels, or the relative risk in this cohort. Age was associated with ethnicity, clinical stage, Gleason score, and PSA levels, as well as the relative risk. Ethnicity was associated with Gleason score and PSA levels as well as the relative risk, but not clinical stage. These findings suggest that obesity is associated with advanced prostate cancer with stage T3 or Gleason score ≥ 7 diseases, and age and ethnicity are important factors that are associated with the clinical features of prostate cancer patients.

Keywords: Prostate cancer, obesity, Gleason score, PSA, clinical stage, ethnicity, age

Introduction

The body mass index (BMI, or Quetelet's index) is defined as the body mass (in kilogram) divided by the square of the body height (in meter), and is a convenient and reliable indicator of obesity [1]. The United States Centers for Disease Control and Prevention has categorized BMI into less than 18.5 (underweight), 18.5 to < 25.0 (normal), 25.0 to < 30.0 (overweight), and ≥ 30.0 (obese). It is estimated that 36.5% of the U.S. adults (≥ 20 years old) are obese during 2011-2014 [2]. Obesity has been associated with type 2 diabetes mellitus, cardiovascular disease, stroke, and several types of cancer [3]. The World Health Organization has predicted a 57% surge of cancer occurrence worldwide in the next 20 years and reducing obesity rate may prevent many cancers [4]. Cancer-specific mortality is significantly increased in obese men and women with many common cancer types, such as cancers of the liver, pancreas, stomach, esophagus, colon and rectum, gallbladder, kidney, prostate, breast, uterus, cervix, and ovary, as well as multiple myeloma and non-Hodgkin's lymphoma [5].

A meta-analysis showed a modest increase in prostate cancer risk at a rate ratio (RR) of 1.05, 95% confidence interval (CI) 1.01-1.08, with increase of every 5 BMI unit [6]. Another study found that overweight was associated with the presence of prostatic intraepithelial neoplasia (PIN) in the initial benign specimen at an odds ratio (OR) of 1.48, 95% CI 0.79-2.77, obesity was associated with PIN at an OR of 2.17, 95% CI 1.13-4.15, and BMI was marginally associated with prostate cancer incidence at an overall OR of 1.15, 95% CI 0.98-1.36, per

Table 1. Clinical features of prostate cancer patients (N = 1788)

Variable	Number of cases	Percentage	Number of cases with records	Number of cases without records
BMI				
BMI < 18.5	219	12.3%	1788	0
18.5 ≤ BMI < 25	310	17.3%		
25 ≤ BMI < 30	671	37.5%		
BMI ≥ 30	588	32.9%		
Age				
Age ≤ 55	335	16.7%	1701	87
55 < Age ≤ 65	798	46.9%		
Age > 65	568	33.4%		
Ethnicity				
Caucasian	971	71.5%	1359	429
African American	388	28.5%		
Stage				
Early Stage (T1/T2)	1125	78.7%	1430	358
Late Stage (T3)	305	21.3%		
Gleason Score				
Gleason < 7	873	48.9%	1786	2
Gleason ≥ 7	913	51.1%		
PSA				
PSA < 10	1104	84.2%	1311	477
10 ≤ PSA ≤ 20	165	12.6%		
PSA > 20	42	3.2%		
Risk Group				
Low Risk	353	34.4%	1027	751
High Risk	674	65.6%		

5 BMI unit difference [7]. In contrast, a study found an inverse association between obesity and prostate cancer at an RR of 0.69, 95% CI 0.52-0.93 [8]. Several studies found that obesity was inversely associated with low-grade (Gleason score < 7) prostate cancer, but positively associated with high-grade (Gleason score ≥ 7) prostate cancer [9, 10]. The World Cancer Research Fund International's Continuous Update Project (CUP) reviewed 104 global studies including 9,855,000 men and 191,000 cases of prostate cancer [11]. The CUP panel concluded that greater body fatness (marked by BMI, waist circumference, and waist-hip ratio) is probably a cause of advanced prostate cancer, the evidence of which is consistent for a dose-response relationship [11]. The plausible mechanisms include increased levels of insulin, leptin, tumor necrosis factor-α, interleukin-6, and C-reactive protein [11]. The advanced prostate cancer in the CUP report was defined as prostate cancers reported in any way of stage 3-4 on the American Joint Committee on Cancer (AJCC) 1992 classification, advanced cancer, advanced or metastatic cancer, metastatic cancer, stage C or D on the Whitmore/Jewett scale, fatal cancer (prostate specific mortality), high stage or grade, and Gleason grade ≥ 7 [11]. No conclusion could be drawn for total or non-advanced prostate cancer by the CUP panel [11]. Nevertheless, it has become a consensus that obesity is definitely associated with prostate cancer metastasis [12, 13], castration resistance [13], and biochemical recurrence as well as prostate cancer-specific mortality [12, 14]. In patients with low-risk prostate cancers under active surveillance, obesity has been associated with a 50% increased risk of pathological progression [15]. Calle et al. reported that prostate cancer mortality's relative risk was 1.08 (95% CI 1.01-1.15) with BMI 25.0-29.9 (overweight), 1.20 (95% CI 1.06-1.36) with BMI 30.0-34.9 (class 1 obese), and 1.34 (95% CI 0.98-1.83) with BMI 35.0-39.9 (class 2 obese) [5]. These findings support an unequivocal conclusion that obesity is associated with prostate cancer progression and mortality.

Louisiana State has the fourth highest obesity rate in the United States according to the United States Centers for Disease Control and Prevention data. Louisiana has the second highest African American population ratio in the United States (32% vs. national average of 13%, the United States Census Bureau 2012), hence African Americans represent the largest minority population in Louisiana. African Americans have the highest age-adjusted obesity rate (48.1%), compared to Hispanics (42.5%), Caucasians (34.5%), and Asians (11.7%) [2]. Coincidentally, African Americans have the highest age-adjusted prostate cancer incidence rate (220.0 per 100,000), compared

Table 2. Clinical features of a subset of prostate cancer patients (N = 1027)

Variable	Number of cases	Percentage
BMI		
BMI < 18.5	11	1.1%
18.5 ≤ BMI < 25	187	18.2%
25 ≤ BMI < 30	439	42.7%
BMI ≥ 30	390	38.0%
Age		
Age ≤ 55	217	21.1%
55 < Age ≤ 65	469	45.7%
Age > 65	341	33.2%
Ethnicity		
Caucasian	586	57.1%
African American	275	26.8%
No records	166	16.1%
Stage		
Early Stage (T1/T2)	792	77.1%
Late Stage (T3)	235	22.9%
Gleason Score		
Gleason < 7	417	40.6%
Gleason ≥ 7	610	59.4%
PSA		
PSA < 10	855	83.3%
10 ≤ PSA ≤ 20	138	13.4%
PSA > 20	34	3.3%
Risk Group		
Low Risk	353	34.4%
High Risk	674	65.6%

to Caucasians (138.6 per 100,000) and other ethnic groups, and prostate cancer mortality in African Americans is 2.4 times of that in Caucasians [16]. The purpose of the present study was to retrospectively analyze the associations between obesity, age, ethnicity, and clinical features of prostate cancer patients treated at the Ochsner Health System located in New Orleans, Louisiana.

Materials and methods

Study population

This study was approved by the Institutional Review Board of the Ochsner Health System (IRB# 2015.122.A). The procedures to obtain the medical records of all patients were in accordance with the Ethical Principles for Medical Research Involving Human Subject as formulated in the World Medical Association Declaration of Helsinki (revised 2008). The medical records of all prostate cancer patients treated at the Ochsner Health System from January, 2001 to March, 2016 were retrieved through the Electronic Research Study Application system. The inclusion criteria were: 1) patients underwent radical prostatectomy; and 2) with pathological reports containing the term "Gleason". The exclusion criteria were: 1) patients diagnosed not having primary prostate cancer by the pathologists; or 2) patients had only biopsy reports. Once included, the patient's electronic and scanned medical records were reviewed manually by two investigators (V.J.W. and D.P.). The patient's body weight and height were retrieved to calculate BMI using the formula: BMI = body weight (kilogram)/body height^2 (meter). The patient's age was the age at the time of surgery. Ethnicity was retrieved as shown in the medical records. The clinical stage was based on AJCC Prostate Cancer Staging (7th edition, 2009). Stage T1 represents clinically inapparent tumor neither palpable nor visible by imaging. Stage T2 represents tumor confined within prostate. Stage T3 represents tumor extends through the prostate capsule. Gleason scores and pre-surgical prostate-specific antigen (PSA) levels were retrieved.

Statistical analysis

The included patients were stratified based on BMI, age, ethnicity, stage, Gleason score, PSA, and overall relative risk. For statistical analysis, BMI cutoff was set as < 30 (non-obese) versus (vs.) ≥ 30 (obese), or as < 25 (underweight and normal weight) vs. ≥ 25 (overweight and obese). Age was stratified per decade according to the assessments of life expectancy following the National Comprehensive Cancer Network (NCCN) guidelines [17]. Elderly patients were combined into one group (> 65 years old) due to lack of values in the 80th decade (with only 17 patients). Ethnicity was stratified into Caucasians and African Americans, the two groups consisting 76% of the included patients. Stage T1 was combined with stage T2 as there were only 17 cases with stage T1. Stage T1/T2 was considered as early stage, while stage T3 was considered as late stage. No stage 4 patients were included. Gleason score was stratified into < 7 vs. ≥ 7. PSA was stratified into < 10 ng/ml, ≥ 10 to ≤ 20 ng/ml,

Table 3. Association analyses in all prostate cancer patients (N = 1788)

Comparison		Analysis			*P*
BMI vs. Age		Age ≤ 55	55 < Age ≤ 65	Age > 65	< 0.0001
	BMI < 30	18.0%	45.2%	36.8%	
	BMI ≥ 30	23.2%	50.4%	26.4%	
BMI vs. Ethnicity		Caucasian	African American		0.0678
	BMI < 30	73.2%	26.8%		
	BMI ≥ 30	68.5%	31.5%		
BMI vs. Stage		Early Stage	Late Stage		0.0147
	BMI < 30	80.63%	19.37%		
	BMI ≥ 30	75.10%	24.90%		
BMI vs. Gleason		Gleason < 7	Gleason ≥ 7		0.0446
	BMI < 30	50.5%	49.5%		
	BMI ≥ 30	45.5%	54.5%		
BMI vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.8809
	BMI < 30	84.5%	12.2%	3.3%	
	BMI ≥ 30	83.7%	13.2%	3.1%	
Age vs. Ethnicity		Caucasian	African American		< 0.0001
	Age ≤ 55	58.3%	41.7%		
	55 < Age ≤ 65	73.8%	26.2%		
	Age > 65	77.6%	22.4%		
Age vs. Stage		Early Stage	Late Stage		0.0015
	Age ≤ 55	81.9%	18.1%		
	55 < Age ≤ 65	80.5%	19.5%		
	Age > 65	72.5%	27.5%		
Age vs. Gleason		Gleason < 7	Gleason ≥ 7		< 0.0001
	Age ≤ 55	55.2%	44.8%		
	55 < Age ≤ 65	51.5%	48.5%		
	Age > 65	39.9%	60.1%		
Age vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.0455
	Age ≤ 55	85.2%	10.7%	4.1%	
	55 < Age ≤ 65	86.5%	10.9%	2.6%	
	Age > 65	80.1%	16.5%	3.4%	
Ethnicity vs. Stage		Early Stage	Late Stage		0.9925
	Caucasian	77.6%	22.4%		
	African American	77.6%	22.4%		
Ethnicity vs. Gleason		Gleason < 7	Gleason ≥ 7		0.0317
	Caucasian	48.3%	51.7%		
	African American	41.9%	58.1%		
Ethnicity vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.0011
	Caucasian	86.2%	11.2%	2.6%	
	African American	77.1%	18.1%	4.8%	

and > 20 ng/ml per NCCN guidelines [17]. NCCN guidelines use stage, Gleason score, and PSA levels to assess the relative risk as very low, low, intermediate, high, and very high [17]. For our statistical analysis, we simplified these different risk groups into two risk groups: low risk and high risk. The low risk group included NCCN's very low risk (meeting all conditions of stage T1C, PSA < 10 ng/ml, and Gleason score ≤ 6), low risk (meeting all conditions of stage T1-T2a and PSA < 10 ng/ml), and intermediate risk (meeting one of the following: stage T2b-

T2c, Gleason score 7, or PSA 10-20 ng/ml). The high risk group included NCCN's high risk (meeting any of the conditions: stage T3a, Gleason score 8-10, PSA > 20 ng/ml), very high risk (meeting any of the conditions: stage T3b-T4, primary Gleason pattern 5, or 4 cores with Gleason score 8-10), and metastatic (any T and N1, or any T and any N with M1) [17]. Statistical analysis was carried out using SAS 9.4 (SAS Institute, Cary, NC, USA). Associative analysis was performed using Pearson's Chi-Squared test. Statistical significance was defined as a *P* value < 0.05.

Results

As shown in **Table 1**, a total of 1788 prostate cancer patients were included in the present study. Approximately 37.5% of the patients were overweight and 32.9% of the patients were obese. Most patients were between 55 to 65 years old (about 46.9%). 76% of the patients had clear records of being either Caucasians or African Americans, the ratio of which was 2.5:1. 78.7% of the patients had stage T1/T2 diseases. Approximately half of the patients had Gleason score < 7, while the other half had Gleason score ≥ 7. A majority (84.2%) of the patients had PSA levels < 10 ng/ml. Based on our simplified risk stratification, 65.5% of the patients belonged to the high risk group, while 34.4% belonged to the low risk group. Except BMI, a portion of the patients were missing records of the rest variables. Approximately 26.7% of the patients did not have pre-surgical PSA records, 24% of the patients did not have ethnicity records, and 20% of the patients did not have clinical stage records (**Table 1**). In order to follow NCCN guidelines [17] to assess the relative risk, we further excluded the patients without records of stage, Gleason score, and PSA, as well as age. Then, we selected a subset of prostate cancer patients (N = 1027) with complete records of BMI, age, stage, Gleason score, and PSA (**Table 2**). Only 16.1% of this cohort missed ethnicity data (**Table 2**). This cohort of patients was stratified into low risk (34.4%) and high risk (65.6%) groups as presented in **Tables 1** and **2**.

As shown in **Table 3**, we found that BMI was associated with age (*P* < 0.001), with less obese patients in the elderly (> 65-year-old) group. African Americans had slightly more obese patients than Caucasians, but the difference was not statistically significant (*P* = 0.0678). BMI was associated with stage (*P* = 0.0147) with more obese patients having late stage diseases. BMI was associated with Gleason score (*P* = 0.0446) with obese patients having more Gleason score ≥ 7. BMI was not associated with PSA levels (*P* = 0.8809). Age was associated with ethnicity (*P* < 0.0001) with more young (≤ 55-year-old) African American patients. Age was associated with clinical stage (*P* = 0.0015) with elderly (> 65-year-old) patients having more late stage diseases. Age was also associated with Gleason score (*P* < 0.0001) with elderly (> 65-year-old) patients having more Gleason score ≥ 7. Age was marginally associated with PSA levels (*P* = 0.0455) with more young (≤ 55-year-old) patients having PSA > 20 ng/ml. Ethnicity was not associated with clinical stage (*P* = 0.9925). However, ethnicity was associated with Gleason score (*P* = 0.0317) with more African American patients having Gleason score ≥ 7. Further, ethnicity was also associated with PSA levels (*P* = 0.0011) with more African American patients having PSA levels > 20 ng/ml (**Table 3**).

As shown in **Table 4**, we did further analyses in the cohort of 1027 patients whose relative risks were assessed. We found that BMI was associated with age and ethnicity, but not with stage, Gleason score, PSA, or the risk group. Age was associated with ethnicity, stage, Gleason score, and the risk group, but not with PSA. Ethnicity was associated with PSA and the risk group, but not with stage or Gleason score (**Table 4**).

In a separate analysis, we used BMI 25 as cutoff. We found that BMI was still associated with age and Gleason score, but not with ethnicity, stage, or PSA in the large cohort of 1788 patients (**Table 5**). In the cohort of 1027 patients, BMI was associated only with age, but not with ethnicity, stage, Gleason score, PSA, or the risk group (**Table 6**).

Discussion

In the present study, we included 1788 prostate cancer patients who were treated with radical prostatectomy at Ochsner Health System during the 15 years between 2001 and 2016. One unique feature of this cohort is that about one third of the patients were African Americans. African American men are three

Table 4. Association analyses in a subset of prostate cancer patients (N = 1027)

		Analysis			*P*
BMI vs. Age		Age ≤ 55	55 < Age ≤ 65	Age > 65	0.0051
	BMI < 30	19.5%	43.6%	36.9%	
	BMI ≥ 30	23.8%	49.0%	27.2%	
BMI vs. Ethnicity		Caucasian	African American		0.0248
	BMI < 30	70.9%	29.1%		
	BMI ≥ 30	63.5%	36.5%		
BMI vs. Stage		Early Stage	Late Stage		0.2350
	BMI < 30	78.3%	21.7%		
	BMI ≥ 30	75.1%	24.90%		
BMI vs. Gleason		Gleason < 7	Gleason ≥ 7		0.5686
	BMI < 30	41.3%	58.7%		
	BMI ≥ 30	39.5%	60.5%		
BMI vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.4823
	BMI < 30	83.3%	12.9%	3.8%	
	BMI ≥ 30	83.1%	14.4%	2.5%	
BMI vs. Risk		Low Risk	High Risk		0.1383
	BMI < 30	67.4%	32.6%		
	BMI ≥ 30	62.8%	37.2%		
Age vs. Ethnicity		Caucasian	African American		< 0.0001
	Age ≤ 55	51.7%	48.3%		
	55 < Age ≤ 65	69.4%	30.6%		
	Age > 65	76.4%	23.6%		
Age vs. Stage		Early Stage	Late Stage		0.0010
	Age ≤ 55	82.5%	17.5%		
	55 < Age ≤ 65	79.5%	20.5%		
	Age > 65	70.4%	29.6%		
Age vs. Gleason		Gleason < 7	Gleason ≥ 7		< 0.0001
	Age ≤ 55	49.8%	50.2%		
	55 < Age ≤ 65	45.6%	54.4%		
	Age > 65	27.9%	72.1%		
Age vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.0820
	Age ≤ 55	84.8%	10.6%	4.6%	
	55 < Age ≤ 65	85.3%	11.9%	2.8%	
	Age > 65	79.5%	17.3%	3.2%	
Age vs. Risk		Low Risk	High Risk		0.0117
	Age ≤ 55	70.5%	29.5%		
	55 < Age ≤ 65	67.8%	32.2%		
	Age > 65	59.5%	40.5%		
Ethnicity vs. Stage		Early Stage	Late Stage		0.6387
	Caucasian	75.3%	24.7%		
	African American	76.7%	23.3%		
Ethnicity vs. Gleason		Gleason < 7	Gleason ≥ 7		0.3901
	Caucasian	39.4%	60.6%		
	African American	36.4%	63.6%		
Ethnicity vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.0002
	Caucasian	85.8%	11.4%	2.7%	
	African American	74.2%	20.7%	5.1%	
Ethnicity vs. Risk		Low Risk	High Risk		0.0020
	Caucasian	67.6%	32.4%		
	African American	56.7%	43.3%		

Table 5. Association analyses using BMI 25 as cutoff in all prostate cancer patients (N = 1788)

		Analysis			*P*
BMI vs. Age		Age ≤ 55	55 < Age ≤ 65	Age > 65	< 0.0001
	BMI < 25	14.4%	44.5%	41.1%	
	BMI ≥ 25	21.8%	47.9%	30.2%	
BMI vs. Ethnicity		Caucasian	African American		0.5852
	BMI < 25	70.2%	29.8%		
	BMI ≥ 25	71.8%	28.2%		
BMI vs. Stage		Early Stage	Late Stage		0.1374
	BMI < 25	81.4%	18.6%		
	BMI ≥ 25	77.7%	22.3%		
BMI vs. Gleason		Gleason < 7	Gleason ≥ 7		0.0440
	BMI < 25	52.6%	47.4%		
	BMI ≥ 25	47.3%	52.7%		
BMI vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.5455
	BMI < 25	85.9%	10.9%	3.2%	
	BMI ≥ 25	83.6%	13.2%	3.2%	

Table 6. Association analyses using BMI 25 as cutoff in a subset of prostate cancer patients (N = 1027)

		Analysis			*P*
BMI vs. Age		Age ≤ 55	55 < Age ≤ 65	Age > 65	0.0043
	BMI < 25	13.6%	45.5%	40.9%	
	BMI ≥ 25	22.9%	45.7%	31.4%	
BMI vs. Ethnicity		Caucasian	African American		0.7971
	BMI < 25	68.9%	31.1%		
	BMI ≥ 25	67.9%	32.1%		
BMI vs. Stage		Early Stage	Late Stage		0.6640
	BMI < 25	78.3%	21.7%		
	BMI ≥ 25	76.8%	23.2%		
BMI vs. Gleason		Gleason < 7	Gleason ≥ 7		0.1763
	BMI < 25	36.4%	63.6%		
	BMI ≥ 25	41.6%	58.4%		
BMI vs. PSA		PSA < 10	10 ≤ PSA ≤ 20	PSA > 20	0.2774
	BMI < 25	82.8%	12.1%	5.1%	
	BMI ≥ 25	83.4%	13.7%	1.8%	
BMI vs. Risk		Low Risk	High Risk		0.3222
	BMI < 25	62.6%	37.4%		
	BMI ≥ 25	66.3%	33.7%		

times more likely to develop prostate cancer and often present with more aggressive disease, however, they are consistently underrepresented in research studies [18]. A previous study has found race and BMI to be able to modify associations of calcium and vitamin D intake with prostate cancer [19]. In African Americans, the association between high calcium intake and aggressive prostate cancer was statistically significant (OR Quartile 1 vs. Quartile 4 = 4.28, 95% CI 1.70-10.80), and there was a strong inverse association between total vitamin D intake and prostate cancer (OR Quartile 1 vs. Quartile 4 = 0.06, 95% CI 0.02-0.54). In Caucasians, there were not any significant associations between either calcium or vitamin D intake and prostate cancer [19]. Further, in analyses stratifying participants based on BMI, there was a strong positive association between calcium and aggressive prostate cancer and a strong inverse association between vitamin D intake and aggressive prostate cancer among men with low BMI (< 27.8), but not among men with high BMI (≥ 27.8) [19]. In the present study, ethnicity was associated with age, Gleason score, and PSA levels. African American patients were younger, had more cases with Gleason score ≥ 7, and had more cases with PSA > 20 ng/ml than Caucasian patients. These findings are consistent with the observation that African Americans have the highest age-adjusted prostate cancer incidence rate and more aggressive prostate cancer compared to Caucasians [16].

Age is a well-established factor for prostate cancer with peak incidence rate at ages between 70 to 74 years old [20]. However, in this cohort, 46.9% of the patients were between 55 to 65 years old, while elderly (> 65 year old) patients consisted of 33.4%. This age shift could be caused by the fact that many elderly patients were not treated with radical prosta-

tectomy, thus they were not included in this study. We found that the elderly patients had more late stage, Gleason ≥ 7, and overall high-risk diseases than younger patients. These findings may be helpful to guide the choices of therapies and follow-up plans for the elderly patients. Besides ethnicity and age, family history is another known risk factor for prostate cancer [21]. However, we could not find many records of family history in this cohort, thus family history was not included as a variable in this study.

Age, family history, and ethnicity are the three known risk factors that cannot be modified. Obesity is a factor that can be modified through diet, exercises, and lifestyle changes. In the cohort of 1788 cases, we found that obese patients had more late stage (T3) and Gleason ≥ 7 diseases than non-obese patients. It is worth pointing out that when BMI 25 was used as cutoff, BMI was still associated with Gleason score, indicating overweight and obese patients had more Gleason score ≥ 7 diseases than underweight and normal weight patients. These findings are consistent with the previous report that obesity is associated with advanced prostate cancer [11]. However, in a smaller cohort of 1027 cases, we did not find any positive associations other than age and ethnicity, which suggests that the statistical power is compromised after the sample size was reduced by about 42%.

In conclusion, the present study suggests that obesity is associated with advanced prostate cancer with stage T3 or Gleason score ≥ 7 diseases, and age and ethnicity are important factors that are associated with the clinical features of prostate cancer patients. One limitation of the present study is that quite large number of patients did not have records of pre-surgical PSA, clinical stage, or ethnicity. We speculate that some PSA data were missing because some patients might have PSA tests in outpatient clinics other than Ochsner Health System, which were not included the medical records. Some clinical stage data were missed likely due to that some pathological reports did not specifically give the stages, thus we were unable to determine the stages retrospectively. Some ethnicity data were missed because either the patients did not report or the physicians failed to record. When the cases with missing data were excluded, the sample size became smaller and adversely affected the statistical power. Another limitation is that there was no patient survival data, which prohibited the analysis on prognosis. This limitation will be remedied by starting a follow-up project to collect patient survival data through Louisiana Tumor Registry, Louisiana Death Registry, and telephone and/or mail communications with the patients or their relatives.

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Disclosure of conflict of interest

None.

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