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Racial and Gender Disparities in the Incidence of Polycythemia Vera: A Nationwide Analysis

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Abstract

Introduction: *Polycythemia vera is a rare type of blood cancer characterized by the overproduction of blood cells in the bone marrow. Left untreated, it can lead to severe complications, recurrent hospitalizations, and reduced life expectancy. Limited research exists on gender, ethnic, and racial disparities in PV occurrence, prompting our analysis across diverse populations.*

Materials and Methods: *We used the National Inpatient Sample 2020 to identify patients admitted with a primary or secondary diagnosis of Polycythemia vera. We analyzed baseline characteristics, including age, gender, income status, and certain comorbid conditions, to evaluate risk associated with PV. We employed a Log Binomial regression model for calculating the Risk ratios while accounting for confounding variables such as demographic characteristics of patients.*

Result: *A total of 20870 patients had PV. The mean age of patients with and without PV was 70+/-13 and 49+/-27 years, respectively. Females and males were 44.25% and 55.74%, respectively, p<0.001. Males had an increased risk of PV compared to females (RR=1.54(1.45-1.64); p<0.001). Compared to white females, white males had an increased risk of PV (RR=1.28(1.19-1.37); p<0.001). Black males (RR=0.69(0.58-0.82);p<0.001) and females (RR=0.46(0.38-0.55); p<0.001) as well as Hispanic males (RR=0.81(0.67-0.98); p=.03) and females (RR=0.44(0.34-0.56); p<0.001) had a decreased Risk of PV compared to white females. Females of other races (RR=0.66(0.46-0.93); p=0.02) had a decreased risk, while males of other races (OR=1.21(0.93-1.56); p=0.14) and Asian males (RR=1.40(0.79-2.47); p=0.24) and females (RR=0.97(0.52-1.82); 0.94) had no difference in the risk of PV. Risk of PV increased with age (36-45: RR(3.85(2.82-5.26), p<0.001; 46-64: RR=7.14(5.42-9.39), p<0.001; >65: RR=9.95(7.49-13.21); p<0.001. Risk of PV also increased with higher Charlson comorbidity index (CI 1: RR=1.46(1.30-1.64); p<0.001); CI 2: RR=1.71(1.52-1.93), p<0.001; CI >/=3: RR=1.89(1.68-2.12); p<0.001. Patients with Hypertension had a high risk of PV (RR=1.11(1.03-1.19); p=0.006) while patients with Diabetes (RR=0.68(0.63-0.74); p<0.001) and End Stage Renal Disease (RR=0.47(0.37-0.59); p<0.001) had lower risk of PV.*

Conclusion: *In conclusion, white males had an increased risk of Polycythemia vera as compared to other races. The risk of PV increases with age. Racial and gender disparities persist in PV, stemming from factors such as lack of awareness, unequal access to healthcare, and numerous other underlying causes. It is crucial to pinpoint the at-risk populations to reduce the incidence of these disparities effectively.*

1. Introduction

Polycythemia vera (PV), also known as erythrocytosis, is a rare form of blood cancer that results in overproduction of red blood cells, or erythrocytes, in the bone marrow. The excess cells accumulate and thicken the blood. This hyperviscosity slows blood flow and can lead to medical emergencies and serious health problems including blood clots, strokes, tissue, and organ damage [1]. In healthy patients without PV, the body naturally regulates the levels of red blood cell, white

blood cell, and platelet production. In patients with PV, the bone marrow overproduces blood cells, increasing the total amount of blood cells [1].

Polycythemia vera has an estimated prevalence of 22 cases per 100,000 individuals. PV is more prevalent in Jews of Eastern European descent compared to other European or Asian populations. PV demonstrates a male preponderance, with an estimated incidence of 2.8 newly diagnosed cases per 100,000 men and 1.3 newly diagnosed cases per 100,000 women, or over a 2:1 ratio, respectively [2].

Polycythemia vera is classified among the Philadelphia-negative chronic myeloproliferative neoplasms. While several studies have been conducted on racial, gender, and socioeconomic disparities in MPN overall, specific investigations into PV are scarce. For example, Khan et al's study focused on racial disparities in complications of MPN patients and utilized data from the University of Illinois. Their sample encompassed a total of 127 Caucasian and non-Caucasian patients. The findings revealed a notable impact of race on outcomes for MPN patients [3].

Despite its impact, gender, racial, and ethnic disparities and its impact on the incidence and risk of polycythemia vera remain under-addressed in medical literature. We hypothesized that disparities in the incidence of PV stem from a combination of factors, including the influence of hormonal contraceptives on females in reproductive age, the role of hormones in thrombosis and hypercoagulability associated with PV development, as well as the impact of specific ethnicities and genetic interplay. These multifaceted elements collectively contribute to variations in incidence across diverse populations. We analyzed the National Inpatient sample to test the hypothesis and uncover additional insights, with a deeper insight into the data to explore various aspects.

2. Methods and Materials

2.1. Data design and source

We used the National Inpatient Sample (NIS), from the year 2020 to conduct our analysis. NIS offers a database of inpatient care across diverse U.S. healthcare facilities. Covering over 21 million hospital admissions annually from 46 states and the District of Columbia, the NIS provides a comprehensive representation, encompassing about 98% of the U.S. population. Notably, entries concerning rehabilitation and federal institutions like Veterans Affairs hospitals are excluded. Administered by the Agency for Healthcare Research and Quality, the NIS, part of the Healthcare Costs and Utilization Project, furnishes an ample sample size conducive for detailed analyses, even regarding rare diseases.

2.2. Study Population

Our analysis involved a thorough examination of discharge records extracted from the National Inpatient Sample (NIS) database, to identify patients with a primary or secondary diagnosis of Polycythemia vera. We utilized the International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS) to identify the population of interest. We excluded patients with incomplete age, race, income, payer status, and diagnosis information.

2.3. Study Variables and Outcomes

We compared the baseline demographics of Patients with PV and calculated the relative risk (RR) of PV across various population subgroups after adjusting for confounding variables. Many co-variables were considered for a robust analysis to minimize the impact of confounding factors. The NIS database provided crucial covariates such as age, race, gender, insurance type, and socioeconomic status determined using zip codes. Additionally, hospital-related variables were considered, including hospital type, teaching status, bed size, and location (urban or rural), along with region-specific data from across the USA. The analysis also incorporated comorbidities such as hypertension, diabetes mellitus, hyperlipidemia, chronic kidney disease, and congestive heart failure based on their respective ICD-10 codes to ensure a comprehensive assessment of contributing factors.

2.4. Statistical Analysis

Categorical data were represented as percentages, while mean values and standard deviations characterized continuous variables. To compare categorical variables across groups, either Pearson's chi-square test or Fisher's exact test was employed, whereas Student's t-test was utilized for continuous variables. We employed the Log-binomial regression to assess PV's relative risk (RR) while accounting for confounding variables. In line with statistical conventions, we deemed a P value of ≤ 0.05 indicative of statistical significance. All statistical analyses were performed using Stata 17 software (College Station, TX, USA), yielding significant insights that effectively addressed research questions and hypotheses, thereby enhancing the overall study quality.

3. RESULTS

3.1. Baseline Characteristics

A total of 6,471,165 cases were analyzed in our study. Of these, 20870 had a diagnosis of Polycythemia Vera (PV). The mean age of patients with and without PV was 70+/-13 and 49+/-27 years, respectively. Females and males were 44.25% and 55.74%, respectively, p<0.001. Among patients with PV, when stratified by age, 1.61% were 18-35, 3.57% were 36-45, 23.91% were 46-64, and 70.91% were >65 years, p<0.001. When stratified by insurance status, 72.21% had Medicare, 6.75% Medicaid, 18.83% private insurance, and 2.21% had no insurance, p<0.001. 24.03% of PV patients were hospitalized in non-teaching hospitals, and 75.97% were in teaching hospitals, p=0.027. When stratified by race, whites were 82.39%, Blacks 7.05%, Hispanics 5.05%, Asians 2.62%, Native Americans 0.54%, and 2.35% were of other races, p<0.001. When further substrate into gender, 38.13% were white females, 46.48% white males, 3.12% were Black females, 4.12% Black males, 1.84% Hispanic females, 3.35% Hispanic males, 0.25% Asian females, 0.3% Asian males, 0.86% Females of other races and 1.56% were males of different races.

	Total no of Cases Excluding PV	Cases with PV	P-value
No. of patients	**6,450,295**	**20870**	
Patient Characteristics			
Age			
Mean Age (SD)	49(27.18)	70(13.65)	<0.001
Gender (%)			<0.001
Male	2891667 (44.83)	11635 (55.75)	
Female	3558628 (55.17)	9235 (44.25)	
Age Distribution (%)			<0.001
18-35	1284254 (19.91)	336 (1.61)	
36-45	613423 (9.51)	745 (3.57)	
46-64	1742225 (27.01)	4990 (23.91)	
>65	2809749 (43.56)	14799 (70.91)	
Race (%)			<0.001
White	4102388 (63.6)	17195 (82.39)	
Black	1021082 (15.83)	1471 (7.05)	
Hispanic	844989 (13.1)	1054 (5.05)	
Asian	201894 (3.13)	547 (2.62)	
Native American	47732 (0.74)	113 (0.54)	
Other	232856 (3.61)	490 (2.35)	
Median household income national quartile for patient zip code (%)			<0.001
$1-$49,999	1955084 (30.31)	4731 (22.67)	
$50,000-$64,999	1748030 (27.1)	5336 (25.57)	
$65,000-$85,999	1480988 (22.96)	5443 (26.08)	
>$86,000	1266193 (19.63)	5362 (25.69)	
Charleston comorbidity index (%)			<0.001
0	2738150 (42.45)	3055 (14.64)	
1	1083005 (16.79)	3969 (19.02)	
2	804997 (12.48)	3926 (18.81)	
3 or more	1824788 (28.29)	9920 (47.53)	
Insurance Provider (%)			<0.001
Medicare	2656231 (41.18)	15070 (72.21)	
Medicaid	1544201 (23.94)	1409 (6.75)	
Private	1964760 (30.46)	3930 (18.83)	
Uninsured	285103 (4.42)	461 (2.21)	
Comorbidities (%)			
Hypertension	1737064 (26.93)	7964 (38.16)	<0.001
Diabetes Mellitus	1323601 (20.52)	4815 (23.07)	<0.001
Chronic Kidney Disease			
CKD2	50957 (0.79)	275 (1.32)	<0.001
CKD3	328320 (5.09)	2246 (10.76)	<0.001
CKD4	112880 (1.75)	670 (3.21)	<0.001

CKD5	14836 (0.23)	65 (0.31)	0.2834
ESRD	205764 (3.19)	415 (1.99)	<0.001
CKD Unspecified	188349 (2.92)	1114 (5.34)	<0.001
Hyperlipidaemia (HLD)	1775121 (27.52)	8916 (42.72)	<0.001
Fluid and Electrolyte Disorders	1491953 (23.13)	6889 (33.01)	<0.001
Discharge Disposition (%)			<0.001
Home	5105408 (79.15)	13701 (65.65)	
Home with home health	1064299 (16.5)	6096 (29.21)	
Skilled nursing facility	151582 (2.35)	712 (3.41)	
Against Medical Advice	129006 (2)	363 (1.74)	
Hospital characteristics (%)			
Bed size of hospital (STRATA)			0.7052
Small	1441641 (22.35)	4804 (23.02)	
Medium	1812533 (28.1)	5814 (27.86)	
Large	3196121 (49.55)	10249 (49.11)	
Hospital location			0.9813
Rural	547630 (8.49)	1776 (8.51)	
Urban	5902665 (91.51)	19094 (91.49)	
Hospital Teaching Status			0.0275
Non-teaching hospital	1664176 (25.8)	5015 (24.03)	
Teaching hospital	4786119 (74.2)	15855 (75.97)	
Region of hospital			<0.001
Northeast	1153958 (17.89)	4520 (21.66)	
Midwest	1410034 (21.86)	4986 (23.89)	
South	2593664 (40.21)	7440 (35.65)	
West	1292639 (20.04)	3926 (18.81)	

3.2. Relative Risk Analysis for Polycythaemia

After adjusting for confounding variables and conducting log-binomial regression, we found that females were associated with decreased risk (RR=0.75(0.70-0.80),p<0.001 and increasing age was associated with increased risk of Polycythaemia Vera (OR=1.01(1.007-1.01),p<0.001. Compared to white females, white males had an increased risk of PV (RR=1.28(1.19-1.37); p<0.001).

Black males (RR=0.69(0.58-0.82);p<0.001) and females (RR=0.46(0.38-0.55); p<0.001) as well as Hispanic males (RR=0.81(0.67-0.98); p=0.03) and females (RR=0.44(0.34-0.56); p<0.001) had a decreased risk of PV compared to white females. Females of other races (RR=0.66(0.46-0.93); p=0.02) had a decreased risk, while males of other races (OR=1.21(0.93-1.56); p=0.14) and Asian males (RR=1.40(0.79-2.47); p=0.24) and females (RR=0.97(0.52-1.82); 0.94) had no difference in the risk of PV. Risk of PV increased with age (36-45: RR(3.85(2.82-5.26), p<0.001; 46-64: RR=7.14(5.42-9.39), p<0.001; >65: RR=9.95(7.49-13.21); p<0.001. Risk of PV also increased with higher Charlson comorbidity index (CI 1: RR=1.46(1.30-1.64); p<0.001); CI 2: RR=1.71(1.52-1.93), p<0.001; CI >/=3: RR=1.89(1.68-2.12); p<0.001. Patients with Hypertension had a high risk of PV (RR=1.11(1.03-1.19); p=0.006) while patients with Diabetes (RR=0.68(0.63-0.74); p<0.001) and End Stage Renal Disease (RR=0.47(0.37-0.59); p<0.001) had lower risk of PV.

	Relative Risk(95% Confidence Interval)		**P-Value**	**Relative Risk (95% Confidence Interval), P-Value**	
Variable	**Unadjusted**	**Adjusted**		**Male**	**Female**
Age	1.04(1.03-1.04)	1.01(1.007-1.01)	<0.001	-	-
Female	0.64(0.60-0.68)	0.75(0.70-0.80)	<0.001	-	-
Race					
White	**Reference**				
Black	0.34(0.30-0.38)	0.49(0.43-0.56)	<0.001	0.69(0.58-0.82),<0.001	0.46(0.38-0.55), <0.001
Hispanic	0.29(0.25-0.34)	0.55(0.47-0.64)	<0.001	0.81(0.67-0.98), 0.03	0.44(0.34-0.56), <0.001
Asian	0.64(0.53-0.78)	0.88(0.72-1.07)	0.223	1.40(0.79-2.47), 0.24	0.97(0.52-1.82), 0.94
Other	0.50(0.41-0.61)	0.81(0.66-0.99)	0.049	.21(0.93-1.56), 0.14	0.66(0.46-0.93), 0.02

4. DISCUSSION

Our study aimed to identify ethnic, gender, age, and socioeconomic disparities in individuals with PV. Our results indicate significant disparities in the incidence and risk of PV across various population subgroups. Males have a higher risk of PV compared to females. White males have the highest risk, followed by white females. Black and Hispanic males and females had a decreased risk of PV compared to white females. Additionally, our study showed that the risk of PV increased with age. Furthermore, hypertension was considered a risk factor for PV, while diabetes and end-stage renal disease were seen as protective factors leading to decreased risk and incidence of PV.

The findings from our analysis coincide with epidemiological estimates. Polycythemia vera demonstrates a male preponderance, with a male-to-female ratio of approximately 2 to 1. Polycythemia vera is also more common in white individuals, particularly Jews of Eastern European descent [2]. This gender disparity is thought to be secondary to the gender influence on JAK2 allele burden which results in various phenotypes of the disease [4]. At the time of diagnosis, studies have found that male PV patients have a higher frequency of homozygous JAK2 genotypes (80% median in males vs. 61% in females) and thus a higher JAK2 variant allele frequency and allele burden in men [5]. As a result of this phenotypic variation, males have a higher predominance for the disease, and the disease presentation may be incredibly variable with as high as 40% of patients being asymptomatic and clinically diagnosed through incidental lab findings [6].

Additionally, a longitudinal study from 1990 to 2012 found that Caucasian patients with PV have been found to have a higher likelihood of disease progression to myelofibrosis in comparison to non-Caucasian patients. Although Caucasian patients may have an increased risk of progression, they were found to have a lower incidence of cardiovascular thrombosis and hemorrhagic complications in comparison to non-Caucasian patients [7]. Furthermore, prior studies have evaluated the racial disparities for patients affected by precursors, such as PV, leading to the development of myelofibrosis and myeloproliferative syndrome. For instance, a study that compared Hispanic patients to Caucasian patients found that 33% of Hispanic patients who developed myelofibrosis underwent eventual transplantation, in comparison to 13% of Caucasian patients. In those who developed myelodysplastic syndrome, Hispanic patients were found to have an overall higher overall survival rate of 47 months in comparison to 37 months in Caucasian patients [8]. These findings are thought to be due to the early diagnosis and younger age of Hispanic patients compared to Caucasian patients which allowed them to receive longer durations of therapy. Interestingly, there is a significantly higher positive hematologic response to therapy in Caucasian patients at 39% in comparison to 10% amongst Hispanics [9]. This further solidifies the importance of timely diagnosis and treatment of PV ultimately being the most favorable factor to prevent progression to myelofibrosis and myelodysplastic syndrome in affected patients.

Our study demonstrates an increased risk of developing Polycythemia vera in aging populations, a finding that is corroborated in the literature. PV is most common around the ages of 50 and 75, with the average age of diagnosis being 60 to 65 years [1]. The aging population with comorbid cardiovascular diseases is susceptible to PV, with thrombotic events representing the main cause of morbidity and mortality for PV patients. The global incidence of both arterial and venous thrombosis is significantly higher among older patients (age > 65) or in those with a previous thrombotic event [10] ECLAP was an observational study that identified age > 65 years as a risk factor for PV as well as a history of thrombotic events as the two main prognostic factors for cardiovascular events in patients with cardiovascular disease. Consequently, the stratification of thrombotic risk can be split into 2 classes: a low-risk group with age < 60 years and no history of thromboses, and a high-risk group, age > 60 and/or with a history of previous thromboses [11].

This retrospective study found that aging as a risk factor is associated with increased allele burden due to acquired mutations of a *JAK2* variant with an increase in age. The *JAK2* V617F mutation is an acquired, somatic mutation seen in patients with myeloproliferative neoplasms and occurs in 90% of PV patients [12]. When looking at a 23andMe general population sample, 70.4% of participants aged 61-112 years were *JAK2* V617F positive, with 41.2% having a myeloproliferative neoplasm in this age range [13]. There are secondary mutations that may contribute to the phenotype of older patients with PV versus younger patients with PV. More than 80% of older patients with PV had secondary mutations in epigenetic regulators *ASXL1*, *TET2*,

DNMT3A, as well as transcription factors *FOXP1* and *NFE2*, and cell cycle regulator *CHEK2*. These secondary driver mutations were not seen in younger patients with PV [14]. To prevent or minimize the progression of PV in aging patients, comprehensive care is crucial as comorbidities such as cardiovascular disease, systemic inflammation, or organ fibrosis increase the risk of PV symptoms and possibly the progression of this myeloproliferative disease [15]

These already present racial and gender disparities persist in PV and often stem from a variety of factors such as a lack of awareness in healthcare, unequal access to healthcare, and several underlying causes. Thus it is imperative to pinpoint at-risk populations and promote health education in these populations to effectively reduce the incidence of disparities in this population. While our study noted an increased risk of PV in white males, the literature suggests that disparities persist in the recognition and treatment of PV in racial and ethnic minority populations as well. Due to the high prevalence of white males in the PV population, there may be an implicit bias that exists for other races or the female gender. By underestimating the prevalence of PV, there is a danger of delaying a PV diagnosis or missing it entirely. Disparities in outcomes also arise from the minority patients themselves lacking awareness of PV, language barriers between them and their healthcare providers, and lack of equal access to novel therapies available [8]. Language barriers can lead to a misinterpretation of clinical findings and the patient being unable to communicate the symptoms they are experiencing. Additionally, these patients may misunderstand the need for compliance with therapy and what compliance looks like. Historically, there has been a lack of representation in minority or female populations, excluding these populations from potentially identifying disease progression, further complicated by the heterogeneity of the disease.

It is important to recognize racial and gender disparities in PV to effectively diagnose and treat the condition. For instance, in one review study, females with PV were found to have a survival disadvantage compared to males [16]. The same study cites that Black PV patients experienced a higher risk of death. This could be a result of problems related to long-term access to healthcare. Additionally, Non-Caucasian patients had an increased risk for thrombosis and hemorrhagic events compared to Caucasian patients [3]. We need to consider the limitations of our study findings carefully. It's important to note that our research is primarily based on an observational study using data from the NIS database and compiles billing data from approximately 20% of US hospitals, offering a valuable but limited perspective that may not fully represent the entire population. It's important to acknowledge that relying solely on ICD-10-CM codes for diagnoses may present limitations, as this approach doesn't allow for confirmation through relevant laboratory test data, subjective patient complaints, and mortality outside the hospital. Therefore, a selection bias of patients with PV cannot be entirely excluded from our analysis.

Additionally, there could be limitations in validating the diagnosis of PV due to coding errors. Most cases of PV could be missed due to the misclassification into Secondary polycythemia or polycythemia due to other factors. As a result, many diagnoses of PV would have been missed and excluded from our study. Despite the study's limitations, it is significant enough to show disparities in individuals with PV related to age, gender, ethnicity, and other socioeconomic factors.

5. Conclusion

The findings of our retrospective study underscore the existence of significant racial and gender disparities in the occurrence of Polycythemia vera (PV). White males exhibit a notably higher risk of PV compared to other demographic groups, highlighting the importance of understanding the underlying factors contributing to this disparity. Additionally, advancing age and comorbid conditions, such as hypertension, emerge as significant risk factors for PV development. These results emphasize the necessity for targeted interventions aimed at mitigating these disparities, which may involve enhancing awareness, improving healthcare access, and addressing systemic inequities. By identifying and addressing the factors driving these disparities, healthcare providers and policymakers can work towards reducing the burden of PV on vulnerable populations and promoting more equitable health outcomes.

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