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Prevalence and Economic Burden of Pulmonary Hypertension and Pulmonary Arterial Hypertension Among the Medicaid Population

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ABSTRACT

Pulmonary hypertension (PH) is defined hemodynamically as a mean pulmonary arterial pressure (mPAP) ≥ 20 mmHg, measured at right heart catheterization (RHC). Pulmonary arterial hypertension (PAH) is defined as a mPAP ≥ 20 mmHg with a pulmonary capillary wedge pressure (PCWP) or left ventricular end-diastolic pressure (LVEDP) of ≤ 15 mmHg and a pulmonary vascular resistance (PVR) > 2 Woods Units (WU). The reported prevalence of PAH in the general population is 0.03–0.05 per 1000 population. However, several studies suggest that the prevalence may be higher among specific sub-populations. Using Medicaid Analytic Extract (MAX) files, we identified Medicaid beneficiaries who were diagnosed with PH or PAH between 2009 and 2012. The prevalence of PH and PAH was calculated for the overall study population and subgroups based on demographics or co-morbidities. We used one-way analysis of variance (ANOVA) tests to compare the differences in hospital bed days and total Medicaid cost across racial subgroups among those with PH and those without PH; Tukey post hoc tests were performed to calculate p-values for comparing White and Black sub-populations. Prevalence rates ranged between 1.7 and 1.8 per 1000 persons, and the PAH prevalence ranged between 0.4 and 0.5 per 1000 persons for the years reviewed. Significant racial/ethnic disparity in PH and PAH prevalence was observed (p-value < 0.001), with Black patients having the highest prevalence and Asian patients having the lowest prevalence. Prevalence of PH and PAH were noted to be higher for the Medicaid population than for the general population for all years reviewed. PH and PAH prevalence was noted to be higher among Blacks compared to Non-Hispanic Whites, while it was significantly lower in Hispanics and Asians. PH/PAH Medicaid patients were noted to account for a greater economic burden compared to the general Medicaid population. Stratifying economic burden by race revealed that American Indian and Alaska Natives with PH had the highest total Medicaid cost for all years reviewed.

1 | Introduction

Pulmonary hypertension (PH) is a condition that involves an increase in pressure within the pulmonary vasculature. PH is diagnosed by a mean pulmonary artery pressure (mPAP) of > 20 mmHg at rest during right heart catheterization (RHC). PH is divided into five sub-groups based primarily on the underlying pathophysiology, which typically involves one or more cardiovascular and/or pulmonary disorders. Pulmonary arterial hypertension (PAH), designated as group 1 PH, is characterized by pulmonary vascular remodeling, involving changes in the intima, media and adventitia [1] and is defined by a mean mPAP > 20 mmHg, a pulmonary arterial wedge pressure (PAWP) ≤ 15 mmHg and a pulmonary vascular

resistance (PVR) > 2 Wood units (WU) [2]. The prevalence of PAH in the United States and Europe is estimated to be between 15 and 50 individuals per million [3]. PH and PAH are often diagnosed at a late stage due to their nonspecific symptoms. When diagnosed at a late stage these conditions, particularly PAH, portend a poor prognosis. The mean survival rate for idiopathic pulmonary arterial hypertension (IPAH), when left untreated, is 2–3 years [4].

Although the reported prevalence for PH and PAH are relatively small, these conditions place a great economic burden on society due to (1) the cost of PAH medications, (2) the debilitation associated with the disease leading to loss of manpower, (3) expenses due to the frequent need for additional resources to support daily living (such as supplemental oxygen, home health services and ambulatory assistance devices), and (4) costs related to an increased need for inpatient care [5, 6]. A systematic literature review published in 2016 revealed high healthcare costs for patients with PAH [7]. The review included 19 articles in the analysis (8 on the economic burden of PAH and 11 on economic evaluation of PAH treatments) and found that for PAH patients the direct healthcare costs per patient per month varied from $2476 to $11,875. However, none of the studies included in the review reported the indirect costs associated with PAH, such as the added utility expenses related to the need for oxygen compressors, or the economic impact from lost days at work for the patient and/or their care provider [7]. A more recent publication evaluating direct and indirect health care expenses from 1293 prevalent and 455 incident patients with PAH found that, compared to patients without PAH, patients with PAH had significantly higher direct and indirect health care resource utilization and costs, as well as productivity loss [8].

The current study was undertaken to provide a more detailed prevalence of PH and PAH in the Medicaid population and to determine the economic burden by this patient cohort.

2 | Methods

This study used a cross-sectional study design to analyze descriptive baseline PH and PAH prevalence and burden of disease among Medicaid beneficiaries. The study population was drawn from 2009 to 2012 Medicaid Analytic Extract (MAX) file obtained from Centers for Medicare and Medicaid Services (CMS). Based on our accessibility to MAX data, we extracted adults at least 18 years old from 29 states (Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and Washington, D.C.) for 2009, which covered 80% of all Medicaid enrollees in the United States and 90% of African American Medicaid enrollees, 49 states (all US states except Kansas and Maine) for 2010, 50 states (all US states except Idaho) for 2011 and all the 51 US states for 2012. Using International Classification of Disease 9 (ICD-9) diagnostic codes 416.8 and 416.0 for PH and 416.0 for PAH, patients with PH/PAH were identified if they had one or more billed claim from inpatient (IP) file or at least two billed claims from outpatient (OP) file. Additional PH/PAH patients were extracted from Prescription Drug (RX) files using active ingredient names “sildenafil,” “epoprostenol,” “treprostinil,” “iloprost,” “adalafil,” “bosentan,” “ambrisentan,” “macitentan,” “riociguat,” and excluding Viagra and Cialis. We further excluded Medicare and Medicaid dual-eligible individuals because necessary encounter data could not be fully accessed from our data set.

Demographic variables included in our study were age, gender, race/ethnicity, and residence status. We classified age into five groups (18–34, 35–44, 45–54, 55–64, 65, and above), and race/ethnicity into seven groups (White, Black, Hispanic/Latino, American Indian/Alaska Native, Asian, Native Hawaiian/Other Pacific Islander, and Other/Unknown). Residence status was acquired from the Area Resource File (ARF) by matching county-level Federal Information Processing Standard (FIPS) codes. Then counties were classified as large metro areas (population ≥ 1 million), small metro areas (population between 250,000 and 1 million), and rural areas (population < 250,000) based on 2012–2013 Rural/Urban Continuum Codes from the Department of Agriculture's Economic Research Services. Certain counties with changed FIPS codes were adjusted. Total hospital bed-days and total Medicaid costs were used to establish burden of disease comparing patients with and without PH/PAH or across racial subgroups, and were presented in dollars adjusted to 2024.

We conducted descriptive analysis with demographic and geographic characteristics. Prevalence of PH/PAH was calculated for the overall study population and subgroups based on demographics. Chi square tests were performed to investigate the difference in PH/PAH patient distribution by demographic variables. One-way analysis of variance (ANOVA) tests was utilized to estimate mean differences of burden of disease across PH/PAH or racial subgroups. We also used ANOVA to compare the differences of burden of disease across racial subgroups among those with PH and those without PH respectively; Tukey post hoc tests were performed to calculate p-values for comparing White and other racial subgroups. The statistically significance level was set at p-value < 0.05 and all analyses were accomplished using SAS 9.4 (SAS Institute, Cary, NC).

3 | Results

In this study, we included 17,375,046, 23,021,268, 24,621,572, and 25,042,163 Medicaid beneficiaries for the year of 2009, 2010, 2011, and 2012, respectively. In each year, the majority of patients were 18–34 years old (2009: 57.2%; 2010: 57.0%; 2011: 56.5%; and 2012: 56.2%), female (2009: 67.9%; 2010: 66.1%; 2011: 65.5%; and 2012: 65.4%), White (2009: 38.2%; 2010: 40.1%; 2011: 40.2%; and 2012: 39.3%), and from large metro areas (2009: 60.3%; 2010: 57.8%; 2011: 57.8%; and 2012: 57.8%) (Table 1).

In 2012, the PH prevalence was 1.0 per 1000 people, and the PAH prevalence was 0.2 per 1000 people for the overall study population. PH/PAH prevalence increased drastically as patients' age increased (p-value < 0.001). The highest prevalences (PH: 4.3/1k, PAH:0.8/1k) were observed among the patients

TABLE 1 | Demographic characteristics of Medicaid beneficiaries from 2009 to 2012.

	2009		2010		2011		2012	
	N	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Total	17,375,046	100	23,021,268	100	24,621,572	100	25,042,163	100
Age								
18–34	9,945,785	57.2	13,127,543	57.0	13,902,247	56.5	14,080,346	56.2
35–44	3,356,952	19.3	4,554,686	19.8	4,871,894	19.8	5,003,789	20.0
45–54	2,397,677	13.8	3,174,167	13.8	3,462,288	14.1	3,498,030	14.0
55–64	1,391,895	8.0	1,799,539	7.8	2,003,405	8.1	2,072,898	8.3
>=65	282,737	1.6	365,333	1.6	381,738	1.6	387,100	1.6
Sex								
Female	11,803,449	67.9	15,218,920	66.1	16,126,840	65.5	16,382,758	65.4
Male	5,571,597	32.1	7,802,348	33.9	8,494,732	34.5	8,659,405	34.6
Race								
White	6,638,070	38.2	9,223,359	40.1	9,901,032	40.2	9,843,223	39.3
Black	3,938,995	22.7	4,829,063	21.0	5,125,681	20.8	5,262,581	21.0
AIAN	196,080	1.1	284,357	1.2	309,638	1.3	308,463	1.2
Asian	685,641	4.0	1,004,374	4.4	1,088,841	4.4	1,126,099	4.5
Hispanic/Latino	4,681,441	26.9	5,941,064	25.8	6,265,543	25.5	6,376,446	25.5
NH/PI	183,028	1.1	248,381	1.1	255,097	1.0	256,809	1.0
Other/Unknown	1,051,791	6.1	1,490,670	6.5	1,675,740	6.8	1,868,542	7.5
Metro								
Big metro	10,469,025	60.3	13,307,413	57.8	14,218,737	57.8	14,476,787	57.8
Small metro	4,662,863	26.8	6,294,498	27.3	6,713,968	27.3	6,873,028	27.5
Rural	2,243,158	12.9	3,419,357	14.9	3,688,867	15.0	3,692,348	14.7

Note: Data for 2009, 2010, 2011, and 2012 was based on 29, 49, 50, and 51 states, respectively.
Abbreviations: %, column percentages; AIAN, American Indian and Alaska Native; NH/PI, Native Hawaiian or Other Pacific Islander; Other/Unknown includes unknown race or more than one race.

aged 55–64 years. There was also significant racial/ethnic disparity in the PH/PAH prevalence (p-value < 0.001), with Black patients having the highest prevalence (PH: 1.6/1k, PAH: 0.3/1k) and Asian patients (PH: 0.4/1k, PAH:0.1/1k) and Hispanic patients having the lowest prevalences (PH: 0.4/1k, PAH:0.1/1k). Patients from large metro areas (PH: 0.9/1k) had slightly lower PH prevalence than those from small metro or rural areas (PH: 1.0/1k), while PAH prevalence was similar for patients from different areas (PAH: 0.2/1k). Similar PH/PAH prevalence and difference across subgroups were also observed for 2009, 2010, and 2011 (Table 2).

In 2012, the average hospital bed days was 0.5, and the average yearly Medicaid cost was 6,997 dollars. Patients with PH or PAH had significantly more hospital bed days (p-value < 0.001) and Medicaid cost (p-value < 0.001) than those without PH/PAH. The highest average hospital bed days was observed for Black patients (mean = 0.6, std = 6.1), while the lowest number was found among NH/PI patients (mean = 0.2, std = 3.2). Black patients (mean = 8437, std = 25,780) also had the highest Medicaid cost than other racial groups. The differences in either hospital bed days or Medicaid cost across racial/ethnic subgroups were both statistically significant (p-value < 0.001). Similar results were observed for 2009, 2010, and 2011 (Table 3). Significant racial differences in disease burden also existed within those with PH or those without PH (Table 4). For patients without PH in 2012, Black patients had the highest hospital bed days (mean = 0.6, std = 6.0) and total Medicaid cost (mean = 8,361, std = 25,546); for those with PH in 2012, Asian patients had the highest hospital bed days (mean = 13.2, std = 32.3) and AIAN patients had the highest total Medicaid cost (mean = 81,874, std = 108,201). The differences in hospital bed days between Black patients and White patients remained statistically significant (p-value < 0.001) across the 4 years (2009, 2010, 2011, and 2012) among those with PH or without PH. Among those without PH, Black patients had significantly higher Medicaid cost than White patients across the 4 years; among those with PH, significant differences in Medicaid cost between Black and White patients were observed for only the years of 2009 and 2011.

4 | Discussion

The prevalence of PH and PAH was higher for the Medicaid population than for the general population for all years reviewed. Although data for only 29 states in the United States was available in 2009, the trends noted at that time were very

TABLE 2 | Rates of pulmonary hypertension or pulmonary arterial hypertension by demographic subgroups for Medicaid beneficiaries from 2009 to 2012.

2009						
	PH			**PAH**		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
Overall	15,894	0.9		4373	0.3	
Age						
18–34	2159	0.2	< 0.001	726	0.1	< 0.001
35–44	2483	0.7		766	0.2	
45–54	5039	2.1		1411	0.6	
55–64	5255	3.8		1253	0.9	
>=65	958	3.4		217	0.8	
Sex						
Female	10,224	0.9	< 0.001	3078	0.3	0.001
Male	5670	1.0		1295	0.2	
Race						
White	6133	0.9	< 0.001	1705	0.3	< 0.001
Black	5841	1.5		1450	0.4	
AIAN	157	0.8		64	0.3	
Asian	303	0.4		121	0.2	
Hispanic/Latino	2210	0.5		674	0.1	
NH/PI	106	0.6		52	0.3	
Other/Unknown	1144	1.1		307	0.3	
Metro						
Large metro	9523	0.9	< 0.001	2745	0.3	< 0.001
Small metro	4056	0.9		999	0.2	
Rural	2315	1.0		629	0.3	
2010						
	PH			**PAH**		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
Overall	20,239	0.9		4989	0.2	
Age						
18–34	2557	0.2	< 0.001	817	0.1	< 0.001
35–44	3036	0.7		855	0.2	
45–54	6410	2.0		1575	0.5	
55–64	6972	3.9		1506	0.8	
>=65	1264	3.5		236	0.6	
Sex						
Female	12,857	0.8	< 0.001	3496	0.2	< 0.001
Male	7382	0.9		1493	0.2	
Race						
White	8366	0.9	< 0.001	2108	0.2	< 0.001
Black	6898	1.4		1525	0.3	
AIAN	275	1.0		74	0.3	
Asian	424	0.4		130	0.1	
Hispanic/Latino	2581	0.4		733	0.1	

(Continues)

TABLE 2 | (Continued)

2010	PH			PAH		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
NH/PI	154	0.6		51	0.2	
Other/Unknown	1541	1.0		368	0.2	
Metro						
Large metro	11,421	0.9	< 0.001	2934	0.2	< 0.001
Small metro	5471	0.9		1245	0.2	
Rural	3347	1.0		810	0.2	
2011						
	PH			**PAH**		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
Overall	22,674	0.9		5,346	0.2	
Age						
18–34	2704	0.2	< 0.001	777	0.1	< 0.001
35–44	3248	0.7		897	0.2	
45–54	7151	2.1		1701	0.5	
55–64	8173	4.1		1734	0.9	
>=65	1398	3.7		237	0.6	
Sex						
Female	14,369	0.9	< 0.001	3774	0.2	< 0.001
Male	8305	1.0		1572	0.2	
Race						
White	9349	0.9	< 0.001	2228	0.2	< 0.001
Black	7823	1.5		1650	0.3	
AIAN	277	0.9		67	0.2	
Asian	474	0.4		134	0.1	
Hispanic/Latino	2701	0.4		762	0.1	
NH/PI	158	0.6		47	0.2	
Other/Unknown	1892	1.1		458	0.3	
Metro						
Large Metro	12,805	0.9	< 0.001	3171	0.2	< 0.001
Small Metro	6092	0.9		1352	0.2	
Rural	3777	1.0		823	0.2	
2012						
	PH			**PAH**		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
Overall	24,203	1.0		5182	0.2	
Age						
18–34	2863	0.2	< 0.001	765	0.1	< 0.001
35–44	3472	0.7		894	0.2	
45–54	7532	2.2		1611	0.5	
55–64	8844	4.3		1701	0.8	
>=65	1492	3.9		211	0.5	

(Continues)

TABLE 2 | (Continued)

2012	PH			PAH		
	N	**per 1000**	***p*-Value**	***N***	**per 1000**	***p*-Value**
Sex						
Female	15,298	0.9	< 0.001	3597	0.2	< 0.001
Male	8905	1.0		1585	0.2	
Race						
White	9726	1.0	< 0.001	2097	0.2	< 0.001
Black	8310	1.6		1660	0.3	
AIAN	266	0.9		59	0.2	
Asian	483	0.4		123	0.1	
Hispanic/Latino	2844	0.4		717	0.1	
NH/PI	163	0.6		41	0.2	
Other/Unknown	2411	1.3		485	0.3	
Metro						
Large Metro	13,649	0.9	< 0.001	3008	0.2	0.925
Small Metro	6750	1.0		1410	0.2	
Rural	3804	1.0		764	0.2	

Note: p-Values were calculated using chi-square tests to compare the differences in the rates across subgroups.
Abbreviations: AIAN, American Indian and Alaska Native; *N*, number of PH/PAH cases; NH/PI, Native Hawaiian or Other Pacific Islander; PAH, pulmonary arterial hypertension; PH, pulmonary hypertension; Other/Unknown includes unknown race or more than one race.

similar to the trends seen when data was available for 48 states in 2010 and when data was available for 50 states in 2011 and 2012. The trends noted in 2009, with data for only 29 states included, were therefore representative of the entire United States.

PH and PAH prevalence rates were highest among persons aged 55–64 years old, followed by those at least 65 years old. PH/PAH prevalence was higher among Blacks compared with Non-Hispanic Whites, while it was significantly lower in Hispanics and Asians. The reason for the racial and ethnic differences in prevalence are uncertain but may be related to racial disparities in the co-morbidities that predispose to PH/PAH (such as hypertension, left heart failure, HIV, and sickle cell disease) [9–13] and/or disparities in access to health care [14, 15].

The increased prevalence of PH/PAH among Blacks identified in the Medicaid population is of particular significance since the prognosis and mortality related to PH/PAH has been shown to be poorer for Blacks compared to other racial groups [16–19]. Multivariate survival analysis of data collected for a cohort of 84 newly diagnosed PAH patients revealed that being Asian or African American was independently associated with an increased risk of death [16]. A retrospective review of mortality data from 1979 to 1996 revealed that African American women had the highest mortality and greatest increase in death related to PAH in the United States [17]. A study analyzing mortality data from the National Vital Statistics System and the National Hospital Discharge Survey between 2001 and 2010 revealed that during the study period, PH death rates were consistently higher for Non-Hispanic Blacks than for Non-Hispanic Whites. They also observed that Non-Hispanic Blacks experienced a significant increase in death rates over the entire study period [18]. A prior study analyzing mortality data from the National Vital Statistics System (NVSS) for 1999–2008 and hospital discharge data from the National Hospital Discharge Survey (NHDS) for 1999–2009 reported a similar trend of higher mortality rates for Blacks compared to Whites during the study period [19]. The reported increase in mortality related to PH/PAH among Blacks coupled with the higher prevalence rates noted for this racial group, highlight the importance of diagnosing this condition and intervening at an early stage for this minority group.

American Indian/Alaska Native, Asian, and Hispanic patients with PH often had longer hospital stays and/or higher annual costs than Whites. The rates of the PH and PAH for these groups tended to be similar or substantially lower than Whites. It might be that more serious cases of PH and PAH are present in the data for these groups than for Whites. The Medicaid data does not allow us to determine if this is the driver for longer stays and higher costs. Studies using EHR could and should be done to test this hypothesis and others to determine what factors are driving these disparities.

These conditions are well-established risk factors for PH and/or PAH [20]. The economic burden was noted to be higher for PH/PAH Medicaid patients compared to the general Medicaid population. When the economic burden was stratified by race, a statistically significant difference was noted across the groups. American Indian and Alaska Natives with PH had the highest total Medicaid cost for all years reviewed, even though this racial group did not account for the highest number of hospital bed days for any of the years review. The racial group with PH that had the highest number of hospital bed days was Blacks in 2009, Hispanics in both 2010 and 2011, and Asians in 2012.

TABLE 3 | Hospital bed days and total yearly Medicaid cost by pulmonary hypertension status or racial subgroups for Medicaid beneficiaries from 2009 to 2012.

2009				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.6 (4.8)	N/A	8008 (29,632)	N/A
Pulmonary hypertension				
Yes	11.5 (21.8)	< 0.001	63,985 (121,442)	< 0.001
No	0.6 (4.8)		7957 (29,368)	
Pulmonary arterial hypertension				
Yes	9.3 (20.4)	< 0.001	70,721 (141,793)	< 0.001
No	0.6 (4.8)		7992 (29,533)	
Race				
White	0.6 (4.7)	ref	9398 (28,401)	ref
Black	0.8 (6.0)	< 0.001	9675 (30,895)	< 0.001
AIAN	0.5 (4.0)	< 0.001	8290 (28,109)	< 0.001
Asian	0.3 (3.7)	< 0.001	5368 (16,115)	< 0.001
Hispanic/Latino	0.4 (3.8)	< 0.001	4804 (29,063)	< 0.001
NH/PI	0.4 (4.0)	< 0.001	5915 (19,650)	< 0.001
Other/Unknown	0.6 (5.0)	0.168	9289 (40,259)	0.008
2010				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.6 (5.4)	N/A	7362 (29,857)	N/A
Pulmonary hypertension				
Yes	13.4 (27.0)	< 0.001	65,515 (119,874)	< 0.001
No	0.6 (5.4)		7311 (29,608)	
Pulmonary arterial hypertension				
Yes	10.1 (23.6)	< 0.001	73,235 (104,098)	< 0.001
No	0.6 (5.4)		7348 (29,805)	
White	0.6 (5.2)	ref	8795 (31,928)	ref
Black	0.8 (7.0)	< 0.001	8937 (29,635)	< 0.001
AIAN	0.6 (4.6)	0.333	8628 (51,184)	0.049
Asian	0.4 (4.7)	< 0.001	4722 (15,343)	< 0.001
Hispanic/Latino	0.4 (4.6)	< 0.001	4134 (26,731)	< 0.001
NH/PI	0.3 (3.8)	< 0.001	5614 (18,284)	< 0.001
Other/Unknown	0.5 (5.0)	< 0.001	8091 (31,380)	< 0.001
2011				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.5 (5.1)	N/A	7136 (26,228)	N/A
Pulmonary hypertension				
Yes	12.5 (24.6)	< 0.001	60,910 (81,406)	< 0.001
No	0.5 (5.0)		7086 (26,072)	

(Continues)

TABLE 3 | (Continued)

2011	Hospital bed days		Total Medicaid cost ($)	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Pulmonary arterial hypertension				
Yes	9.8 (23.5)	< 0.001	70,115 (93,971)	< 0.001
No	0.5 (5.1)		7122 (26,178)	
Race				
White	0.5 (4.9)	ref	8459 (26,269)	ref
Black	0.7 (6.4)	< 0.001	8698 (27,343)	< 0.001
AIAN	0.5 (4.3)	< 0.001	8036 (27,854)	< 0.001
Asian	0.3 (4.3)	< 0.001	4638 (14,668)	< 0.001
Hispanic/Latino	0.4 (4.3)	< 0.001	3972 (25,479)	< 0.001
NH/PI	0.3 (3.5)	< 0.001	5360 (18,388)	< 0.001
Other/Unknown	0.5 (4.9)	0.895	8091 (30,341)	< 0.001
2012	**Hospital bed days**		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.5 (4.8)	N/A	6997 (25,836)	N/A
Pulmonary hypertension				
Yes	11.3 (24.2)	< 0.001	54,008 (93,717)	< 0.001
No	0.5 (4.8)		6952 (25,642)	
Pulmonary arterial hypertension				
Yes	8.5 (22.1)	< 0.001	58,367 (84,680)	< 0.001
No	0.5 (4.8)		6987 (25,799)	
Race				
White	0.5 (4.7)	ref	8269 (26,065)	ref
Black	0.6 (6.1)	< 0.001	8437 (25,780)	< 0.001
AIAN	0.5 (4.2)	0.672	8311 (33,136)	0.971
Asian	0.3 (4.4)	< 0.001	4674 (13,595)	< 0.001
Hispanic/Latino	0.3 (4.1)	< 0.001	3862 (24,575)	< 0.001
NH/PI	0.2 (3.2)	< 0.001	5958 (18,690)	< 0.001
Other/Unknown	0.5 (4.8)	< 0.001	8275 (32,254)	0.998

Note: p-Values were calculated using one-way analysis of variance to compare the differences in the hospital bed days or Medicaid cost across subgroups; ref, White was the reference group when Tukey post hoc tests were performed to calculate *p*-values for comparing other racial subgroups with White.
Abbreviations: AIAN, American Indian and Alaska Native; NH/PI, Native Hawaiian or Other Pacific Islander; Std, standard deviation; Other/Unknown includes unknown race or more than one race.

Given the higher prevalence of PH/PAH noted among Blacks and the high economic burden attributed to PH/PAH, greater attention should be given to addressing the co-morbidities related to PH/PAH among Blacks to prevent progression to PH/PAH. A critical component of addressing the burden of PH/PAH involves raising awareness of the need to screen for PH/PAH among Blacks/African Americans. In fact, perhaps the threshold for PH/PAH screening among Blacks/African Americans should be lower since this racial group has a higher prevalence rate of PH/PAH.

PH/PAH prevalence is higher in the Medicaid population than in the general US population, particularly among Black Medicaid participants. The economic burden of PH/PAH in the Medicaid population was highest for American Indian and Alaska Natives. Research is needed to better characterize the burden of PH/PAH among these high-risk sub-groups, as well as to determine specific risk-group thresholds at which PH/PAH screening might be implemented.

TABLE 4 | Hospital bed days and total yearly Medicaid cost by pulmonary hypertension status and racial subgroups for Medicaid beneficiaries from 2009 to 2012.

2009				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.6 (4.8)	N/A	8008 (29,632)	N/A
Pulmonary hypertension				
White	10.8 (21.2)	ref	60,163 (82,294)	ref
Black	13.1 (24.2)	< 0.001	66,948 (87,003)	0.036
AIAN	10.8 (21.9)	0.998	87,475 (123,769)	0.079
Asian	8.4 (17.6)	0.531	50,998 (69,684)	0.86
Hispanic/Latino	10.2 (19.0)	0.929	70,862 (250,941)	0.007
NH/PI	6.7 (15.1)	0.479	51,030 (68,856)	0.988
Other/Unknown	10.5 (17.9)	0.993	57,475 (64,476)	0.993
No pulmonary hypertension				
White	0.6 (4.6)	ref	9351 (28,262)	ref
Black	0.7 (6.0)	< 0.001	9590 (30,656)	< 0.001
AIAN	0.5 (4.0)	< 0.001	8226 (27,812)	< 0.001
Asian	0.3 (3.7)	< 0.001	5348 (16,024)	< 0.001
Hispanic/Latino	0.4 (3.8)	< 0.001	4773 (28,518)	< 0.001
NH/PI	0.4 (4.0)	< 0.001	5889 (19,556)	< 0.001
Other/Unknown	0.6 (5.0)	0.280	9237 (40,194)	0.004
2010				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.6 (5.4)	N/A	7362 (29,857)	N/A
Pulmonary hypertension				
White	11.4 (22.4)	ref	62,662 (83,711)	ref
Black	15.3 (30.8)	< 0.001	66,884 (87,937)	0.314
AIAN	12.7 (19.0)	0.987	89,208 (106,927)	0.006
Asian	12.6 (27.2)	0.978	53,689 (79,674)	0.742
Hispanic/Latino	16.5 (31.6)	< 0.001	74,679 (249,595)	< 0.001
NH/PI	6.5 (21.6)	0.275	50,521 (90,057)	0.876
Other/Unknown	11.5 (24.1)	0.998	60,055 (82,509)	0.986
No pulmonary hypertension				
White	0.6 (5.2)	ref	8746 (31,801)	ref
Black	0.8 (6.9)	< 0.001	8854 (29,388)	< 0.001
AIAN	0.6 (4.6)	0.221	8550 (51,040)	0.009
Asian	0.4 (4.7)	< 0.001	4702 (15,226)	< 0.001
Hispanic/Latino	0.4 (4.5)	< 0.001	4103 (26,185)	< 0.001
NH/PI	0.3 (3.7)	< 0.001	5586 (18,118)	< 0.001
Other/Unknown	0.5 (4.9)	< 0.001	8037 (31,239)	< 0.001
2011				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.5 (5.1)	N/A	7136 (26,228)	N/A
Pulmonary hypertension				

(Continues)

TABLE 4 | (Continued)

2011	Hospital bed days		Total Medicaid cost ($)	
	Mean (std)	*p*-Value	Mean (std)	*p*-Value
White	10.7 (20.1)	ref	58,886 (78,625)	ref
Black	14.1 (27.1)	< 0.001	63,461 (81,635)	0.005
AIAN	12.7 (26.4)	0.832	81,447 (116,555)	< 0.001
Asian	13.6 (31.9)	0.166	54,274 (88,638)	0.893
Hispanic/Latino	14.9 (29.7)	< 0.001	61,918 (85,169)	0.612
NH/PI	7.5 (16.2)	0.670	55,799 (87,620)	0.993
Other/Unknown	11.6 (23.6)	0.732	58,013 (79,091)	0.998
No pulmonary hypertension				
White	0.5 (4.8)	ref	8411 (26,124)	ref
Black	0.7 (6.3)	< 0.001	8614 (27,092)	< 0.001
AIAN	0.5 (4.3)	< 0.001	7970 (27,561)	< 0.001
Asian	0.3 (4.3)	< 0.001	4616 (14,518)	< 0.001
Hispanic/Latino	0.4 (4.2)	< 0.001	3947 (25,395)	< 0.001
NH/PI	0.3 (3.5)	< 0.001	5328 (18,221)	< 0.001
Other/Unknown	0.5 (4.9)	0.468	8035 (30,195)	< 0.001
2012				
	Hospital bed days		**Total Medicaid cost ($)**	
	Mean (std)	***p*-Value**	**Mean (std)**	***p*-Value**
Overall	0.5 (4.8)	N/A	6,997 (25,836)	N/A
Pulmonary hypertension				
White	10.1 (21.8)	ref	53,560 (80,831)	ref
Black	12.9 (27.1)	< 0.001	56,246 (77,232)	0.467
AIAN	13.1 (27.0)	0.421	81,874 (108,201)	< 0.001
Asian	13.2 (32.3)	0.079	45,819 (67,762)	0.566
Hispanic/Latino	11.7 (24.8)	0.04	48,625 (166,654)	0.169
NH/PI	4.3 (19.3)	0.037	30,980 (58,446)	0.037
Other/Unknown	9.8 (19.1)	0.997	54,577 (76,707)	0.998
No pulmonary hypertension				
White	0.5 (4.6)	ref	8224 (25,914)	ref
Black	0.6 (6.0)	< 0.001	8361 (25,546)	< 0.001
AIAN	0.5 (4.1)	0.547	8248 (32,927)	0.998
Asian	0.3 (4.3)	< 0.001	4656 (13,499)	< 0.001
Hispanic/Latino	0.3 (4.0)	< 0.001	3842 (24,309)	< 0.001
NH/PI	0.2 (3.2)	< 0.001	5943 (18,628)	< 0.001
Other/Unknown	0.5 (4.7)	< 0.001	8215 (32,114)	0.999

Note: p-Values were calculated using one-way analysis of variance to compare the differences in the hospital bed days or Medicaid cost across racial subgroups; ref, White was the reference group when Tukey post hoc tests were performed to calculate *p*-values for comparing other racial subgroups with White.
Abbreviations: AIAN, American Indian and Alaska Native; NH/PI, Native Hawaiian or Other Pacific Islander; Other/Unknown includes unknown race or more than one race; Std, standard deviation.

5 | Limitations

The use of ICD codes to identify individuals diagnosed with PH and PAH in our study may have affected the accuracy with which individuals were classified. This study limitation is similar to that noted for other studies that have utilized ICD coding to identify cases [21]. Another important limitation to take into consideration with regard to this study is the fact that most of the studies reviewed for our analysis were conducted before the change in the hemodynamic definition of PH. Therefore, the study may have underestimated the actual prevalence of PH during this period reviewed. With a new hemodynamic

threshold of mPAP > 20 mmHg (previously 25 mmHg) the potential exists to identify more cases of PH, at an earlier stage of the disease, and permit introduction of therapeutics at an earlier timeframe with potential to improve outcomes.

Author Contributions

All authors were involved in the conception or design of the analysis, interpretation of the data, and review and approval of the manuscript.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

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