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ORIGINAL ARTICLE

Social determinants of health in pulmonary embolism management and outcome in hospitals: Insights from the United States nationwide inpatient sample

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Abstract

Background: The role of social determinants in the treatment and course of acute pulmonary embolism (PE) is understudied.

Objective: To investigate the association between social determinants of health with in-hospital management and early clinical outcomes following acute PE.

Methods: We identified hospitalizations of adults with acute PE discharge diagnosis from the nationwide inpatient sample (2016-2018). Multivariable regression was used to investigate the association between race/ethnicity, type of expected primary payer, and income with the use of advanced PE therapies (thrombolysis, catheter-directed treatment, surgical embolectomy, extracorporeal membrane oxygenation), length of stay, hospitalization charges, and in-hospital death.

Results: A total of 1,124,204 hospitalizations with a PE diagnosis were estimated from the 2016–2018 nationwide inpatient sample, corresponding to a hospitalization rate of 14.9/10,000 adult persons-year. The use of advanced therapies was lower in Black and Asian/Pacific Islander (vs. White patients: adjusted odds ratio [$OR_{adjusted}$], 0.87; 95% confidence interval [CI], 0.81–0.92 and $OR_{adjusted}$ 0.76; 95% CI, 0.59–0.98) and in Medicare- or Medicaid-insured (vs. privately-insured; $OR_{adjusted}$, 0.73; 95% CI, 0.69–0.77 and $OR_{adjusted}$, 0.68; 95% CI, 0.63–0.74), although they had the greatest length of stay and hospitalization charges. In-hospital mortality was higher in the lowest income quartile (vs. highest quartile; $OR_{adjusted}$, 1.09; 95% CI, 1.02–1.17). Among high-risk PE, patients of other than the White race had the highest in-hospital mortality.

Conclusion: We observed inequalities in advanced therapies used for acute PE and higher in-hospital mortality in races other than White. Low socioeconomic status was also associated with lesser use of advanced treatment modalities and greater in-hospital mortality. Future studies should further explore and consider the long-term impact of social inequities in PE management.

KEYWORDS
pulmonary embolism, social determinants of health, inequality, disparity

Essentials

- Social determinants of treatment and the course of acute pulmonary embolism (PE) are understudied.
- We studied PE hospitalizations in the United States nationwide inpatient sample.
- Inequalities in advanced therapies and mortality exist related to race and socioeconomic status.
- Future studies should explore the long-term impact of social inequities in PE management.

1 | INTRODUCTION

Social determinants of health encompass "the circumstances in which people are born, grow, live, work, and age, and the systems put in place to deal with illness" [1] and include economic status, race and ethnicity, culture and language, residential environment, social support and inclusion, and access to health care. In cardiovascular diseases, tremendous progress has been achieved in reducing mortality over the past several decades. However, the burden of disease remains vast, and in absolute numbers, cardiovascular disease is the leading cause of death in the US [2]. Many disadvantaged population groups are disproportionately burdened with high cardiovascular risk and outcomes, which may, in turn, further contribute to racial and socioeconomic inequalities [3,4].

Pulmonary embolism (PE) is the third most common cause of cardiovascular disease mortality, accounting for a major burden of disease in low-, middle-, and high-income countries [5,6]. In the US, PE-related mortality rates plateaued during the last decade while increasing among young and middle-aged adults [7,8]. There are disparities in the incidence rates and mortality of acute PE across racial and ethnic groups [8,9]. In contrast, high socioeconomic status is associated with low venous thromboembolism (VTE) risk [10]. However, evidence on associations of the broad range of social determinants of health with PE and its management is sparse and not well characterized.

This investigation aimed to assess the associations of several social determinants of health, including socioeconomic status, race and ethnicity, insurance status, and place of residence, with in-hospital management and outcomes of acute PE.

2 | METHODS

We used data from the nationwide inpatient sample (NIS) in 2016, 2017, and 2018, provided by the Agency for Healthcare Research and Quality. The NIS database is developed for the Healthcare Cost and Utilization Project (HCUP) and is the largest publicly available all-payer inpatient healthcare database in the US. This data represents ~97% of the US population and contains a 20% stratified sample of discharges from US hospitals that participate in the HCUP, excluding rehabilitation and long-term acute care hospitals. The database contains only de-identified data, and no institutional review board approval was required for this analysis. Additional information on the NIS is available at the HCUP NIS Database Documentation website (www.hcup-us.ahrq.gov).

2.1 | Study population and data definition

The NIS datasets include up to 40 diagnoses and 25 procedures for each discharge record, which are coded according to the International Classification of Diseases, 10th revision (ICD-10-CM for diagnoses and ICD-10-PCS for procedures). We identified all hospitalizations of adult (aged ≥18 years) patients with a PE discharge diagnosis as defined by the ICD-10-CM I26.0 and I26.9. We defined high-risk acute PE as hospitalizations with an additional diagnosis of shock (ICD-10-CM R57.0, R57.9), ventilator support (ICD-10-CM Z99.11), cardiac arrest (ICD-10-CM I46.8, I46.9), need for cardiopulmonary resuscitation (ICD-10-PCS 5A12012), or vasopressor use (ICD-10-PCS 3E033XZ, 3E043XZ). We defined a primary PE diagnosis as a first-listed diagnosis code for acute PE (ICD-10-CM I26.0, I26.9) or as a second-listed after a diagnosis code for deep vein thrombosis (ICD-10-CM I82.2, I82.4, I82.9).

The use of advanced therapy during the hospitalization for PE was defined as the use of at least one of the following: systemic thrombolysis, catheter-directed treatment (including catheter-directed thrombolysis and percutaneous thrombectomy), surgical embolectomy, and extracorporeal membrane oxygenation. The use of inferior vena cava filters was studied separately. We defined the following complications during index PE hospitalization: any bleeding, nontraumatic intracranial hemorrhage (ICD-10-CM I62.), or any adverse effect of thrombolytic drugs (T45.615A) or anticoagulants (T45.515A). The ICD-10 codes used for the definition of the aforementioned variables and patient comorbidities are presented in Supplementary Table 1.

The following social determinants of health were considered: race and ethnicity (non-Hispanic White, and non-White including Black, Hispanic, Asian or Pacific Islander, Native American, or other race), type of primary payer (Medicare, Medicaid, private insurance, or other forms), and household income (defined as a median household income of residents in the patient's zip code in each respective year and expressed in quartiles. The place of residence was defined as urban, suburban, and rural [11]. Hospitals were categorized according to location and teaching status (rural, urban teaching, urban nonteaching) and bedside capacity (small, medium, and large).

2.2 | Outcomes

We focused on the use of any advanced therapy for acute PE, in-hospital mortality, length of stay, and total charges during the hospital stay.

2.3 | Statistical analysis

The proportions of missing data were below 3% for all variables, and we assumed that the missing data were missing at random; hence, we performed a complete case analysis. Categorical variables were described as counts and percentages, whereas continuous variables were described with medians and interquartile range (IQR). We used the US Census Bureau population counts for adults ≥18 years to estimate crude hospitalization and mortality rates for PE by racial group or ethnicity, and we estimated 95% confidence intervals (CIs) using the Wilson score interval with continuity correction. Logistic regression was used to calculate the odds ratios for the use of advanced therapies and all-cause in-hospital mortality based on age, sex, race and ethnicity, type of health insurance, and income. We used linear regression with the same independent variables to examine their association with the length of stay and total charges during the hospital stay. We compared all results for those with normal or high-risk PE. All models were additionally adjusted for variables considered likely to affect the outcome measures, including high-risk PE, primary versus secondary diagnosis of PE, place of residence, hospital location/teaching status, hospital bed size, and history of hypertension, diabetes mellitus, myocardial infarction, cerebrovascular disease, congestive heart failure, renal disease, chronic pulmonary disease, cancer, and dementia. We applied the discharge-level weights provided on the HCUP database to produce national estimates for all analyses. We used clustered covariance estimation to compute clustered CIs to consider the stratification and hospitals defining the clusters. A two-sided p-value <0.05 indicated statistical significance. We used R (R Project for Statistical Computing, version 3.6.3.) for the statistical analysis.

3 | RESULTS

We estimated a total of 1,124,204 hospitalizations with a PE diagnosis during 2016–2018, of which 615,570 (54.8%) had PE as the primary cause of hospitalization and 66,570 (5.9%) had high-risk PE. Most hospitalizations occurred in private, not-for-profit, urban, teaching, and large-sized hospitals. Hospitalized patients had a median age of 65 (IQR, 52–75) years, 51% were women, and 29% were of non-White race. The primary payer was Medicare in 52%, private or other insurance in 34%, and Medicaid in 14%; 29% resided in zip codes with household income in the lowest quartile. The baseline characteristics of the overall population and those with high-risk PE are presented in Table 1.

The overall hospitalization rate for acute PE was 14.9 per 10,000 adult person-years (95% CI, 14.8–14.9). The hospitalization rate was lower in Asian or Pacific Islanders (3.0 per 10,000 adult person-years; 95% CI, 2.9–3.1), Native American (5.6 per 10,000 adult person-years; 95% CI, 5.4–5.7), Hispanic (6.0 per 10,000 adult person-years; 95% CI, 5.9–6.1), and White patients (13.1 per 10,000 adult person-years; 95% CI, 13.1–13.2) vs. Black patients (20.1 per 10,000 adult person-years; 95% CI, 20.0–20.2). Patients of races other than White were more likely to be younger, to belong in the lowest income category (except Asian), to be covered with Medicaid insurance, and to live in urban areas (except Native American) (Figure 1). A detailed report of the baseline characteristics of patients according to race is presented in Supplementary Table 2. All races other than White (except for Native Americans) compared with White race were associated with greater odds of presenting with high-risk PE than less severe PE. High-risk PE events were more prevalent in urban teaching hospitals of large size (Supplementary Figure 1).

3.1 | Use of advanced therapies

The use of advanced therapies was reported in 5.5% of all hospitalizations for acute PE (Table 2) and in 19% of hospitalizations for high-risk PE. The use of the different types of advanced therapies is presented in Figure 2. Advanced therapies were used less frequently in older patients, female patients, and Black and Asian/Pacific Islander patients; similarly, it was less frequent in patients with Medicare or Medicaid insurance (vs. private insurance). Risk estimates and reference strata are presented in Figure 3. Among high-risk PE patients, the use of any advanced therapy was greater in women, less likely in the Asian/Pacific Islander race, in patients with Medicaid insurance, and in patients in the lowest quartile of income; Figure 3. All types of advanced therapy were used less often among patients with Medicaid (Supplementary Figures 2–6; this also regarded high-risk PE patients (Supplementary Figure 2–6).

3.2 | In-hospital case fatality rate and mortality

The overall in-hospital case fatality rate was 6.4% (72,305 deaths recorded among 1,124,204 hospitalizations): corresponding to a crude mortality rate of 0.96 (95% CI, 0.95–0.97) deaths per 10,000 adult person-years. Older age, as well as Asian/Pacific Islander race compared with White, and the lowest quartile of income in the zip code (vs. highest quartile), was significantly associated with increased in-hospital mortality in the overall population, while Medicaid insurance (vs. private insurance) showed a strong trend toward increased mortality (Figure 4). For high-risk patients, the case fatality rate was 50% (33,200 out of 66,570 hospitalizations). In this group, factors

TABLE 1 Baseline characteristics of pulmonary embolism hospitalizations.

Characteristic	Overall, N = 1,124,204[a]	Not high-risk PE, N = 1,057,634[a]	High-risk PE, N = 66,570[a]
Age	64 (52, 75)	64 (52, 75)	65 (54, 75)
Female	578,030 (51%)	546,210 (52%)	31,820 (48%)
Race/Ethnicity			
White	771,780 (71%)	730,175 (72%)	41,605 (65%)
Black	195,045 (18%)	181,290 (18%)	13,755 (22%)
Hispanic	72,420 (6.7%)	67,530 (6.6%)	4,890 (7.7%)
Asian/Pacific Islander	13,985 (1.3%)	12,650 (1.2%)	1,335 (2.1%)
Native -American	4,880 (0.4%)	4,605 (0.5%)	275 (0.4%)
Other	26,520 (2.4%)	24,585 (2.4%)	1,935 (3.0%)
Place of residence			
Urban	589,320 (53%)	552,040 (52%)	37,280 (56%)
Suburban	228,755 (20%)	215,785 (20%)	12,970 (20%)
Rural	301,505 (27%)	285,540 (27%)	15,965 (24%)
Health insurance			
Private Insurance	300,840 (27%)	285,775 (27%)	15,065 (23%)
Medicare	588,305 (52%)	551,645 (52%)	36,660 (55%)
Medicaid	156,240 (14%)	146,115 (14%)	10,125 (15%)
Other	77,100 (6.9%)	72,535 (6.9%)	4,565 (6.9%)
Household income			
Income Q1	323,775 (29%)	303,110 (29%)	20,665 (32%)
Income Q2	293,340 (27%)	276,740 (27%)	16,600 (25%)
Income Q3	266,735 (24%)	251,610 (24%)	15,125 (23%)
Income Q4	220,260 (20%)	207,360 (20%)	12,900 (20%)
Hospital bed size			
Large size	589,855 (52%)	549,455 (52%)	40,400 (61%)
Medium size	321,235 (29%)	303,625 (29%)	17,610 (26%)
Small size	213,115 (19%)	204,555 (19%)	8,560 (13%)
Hospital location/teaching status			
Urban teaching	775,780 (69%)	723,840 (68%)	51,940 (78%)
Urban non-teaching	251,680 (22%)	239,905 (23%)	11,775 (18%)
Rural	96,745 (8.6%)	93,890 (8.9%)	2,855 (4.3%)
Hospital ownership			
Private, not-for-profit	855,565 (76%)	805,460 (76%)	50,105 (75%)
Public	128,585 (11%)	119,900 (11%)	8,685 (13%)
Private, investor-owned	140,055 (12%)	132,275 (13%)	7,780 (12%)
Weekend admission	258,855 (23%)	242,520 (23%)	16,335 (25%)
Comorbidities			
Hypertension	677,605 (60%)	637,305 (60%)	40,300 (61%)
Diabetes mellitus	272,960 (24%)	253,015 (24%)	19,945 (30%)

(Continues)

TABLE 1 (Continued)

Characteristic	Overall, N = 1,124,204[a]	Not high-risk PE, N = 1,057,634[a]	High-risk PE, N = 66,570[a]
Myocardial infarction	103,130 (9.2%)	90,685 (8.6%)	12,445 (19%)
Cerebrovascular disease	70,345 (6.3%)	62,340 (5.9%)	8,005 (12%)
Congestive heart failure	238,495 (21%)	211,500 (20%)	26,995 (41%)
Renal disease	161,970 (14%)	146,805 (14%)	15,165 (23%)
Chronic pulmonary disease	308,960 (27%)	291,325 (28%)	17,635 (26%)
Cancer	319,755 (28%)	302,970 (29%)	16,785 (25%)
Dementia	69,390 (6.2%)	65,595 (6.2%)	3,795 (5.7%)

PE, pulmonary embolism; Q1-Q4, quartiles first to fourth (low income to high income).
[a]Median (IQR); n/N (%).

related to increased in-hospital mortality included older age and all races other than White (except for Native Americans) compared with the White race (Figure 4).

3.3 | Length of stay and total charges

Overall, the median length of stay in the hospital was 4 days (IQR 2-8 days). Among patients discharged alive, the length of stay was significantly longer in Asian/Pacific Islander patients (vs. White patients) and patients with Medicare or Medicaid insurance (vs. private insurance), as well as patients in the lowest income quartile in their zip code. The shorter stay was recorded among women and older patients (Table 3).

Overall, the median total charges in the hospital amounted to $40,469 (IQR $21,366-84,828). Among patients discharged alive, the total charges were significantly greater in Hispanic and Asian/Pacific Islander patients (vs. White patients), and patients with Medicare or Medicaid insurance (vs. private insurance), whereas they were lower in older and female patients (Table 3).

4 | DISCUSSION

In this retrospective study of the NIS during 2016–2018, we observed several disparities in the in-hospital management and outcomes of patients with PE that were associated with social

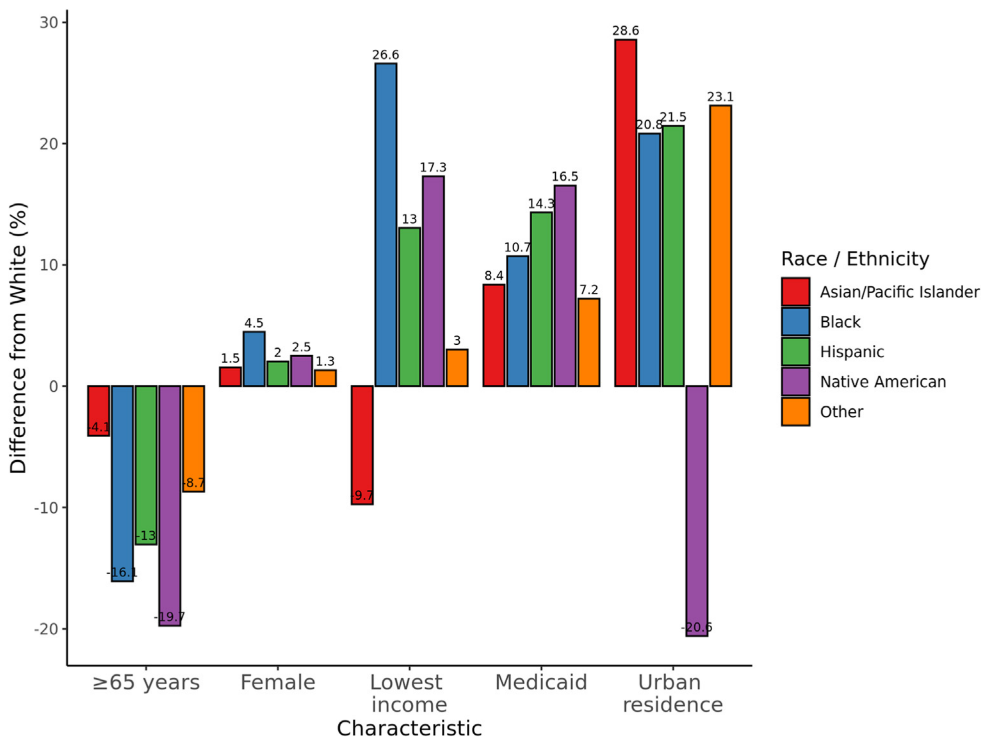

FIGURE 1 Differences in the prevalence of baseline characteristics among patients with non-White ethnicity/race (Asian/Pacific Islander, Black, Hispanic, Native American, Other) and White race.

TABLE 2 Outcomes in hospitalized patients with acute pulmonary embolism.

Characteristic	Overall, N = 1,124,204[a]	Not high-risk PE, N = 1,057,634[a]	High-risk PE, N = 66,570[a]	P value[b]
In-hospital mortality	72,305 (6.4%)	39,105 (3.7%)	33,200 (50%)	<0.001
Length of stay, days	4 (2, 8)	4 (2, 8)	8 (3, 17)	<0.001
Total charge, USD	40,469 (21,366, 84,828)	38,345 (20,722, 77,740)	124,160 (58,797, 266,107)	<0.001
Use of any advanced therapy	61,320 (5.5%)	48,375 (4.6%)	12,945 (19%)	<0.001
Bleeding	165,425 (15%)	144,150 (14%)	21,275 (32%)	<0.001
Adverse effects of thrombolysis	890 (<0.1%)	610 (<0.1%)	280 (0.4%)	<0.001
Intracranial hemorrhage (non-traumatic)	3,880 (0.3%)	3,175 (0.3%)	705 (1.1%)	<0.001
Adverse effects of anticoagulants	13,660 (1.2%)	12,545 (1.2%)	1,115 (1.7%)	<0.001

ECMO, extracorporeal membrane oxygenation; PE, pulmonary embolism.
[a]n/N (%); Median (IQR).
[b]chi-squared test adjusted by a design effect estimate: Wilcoxon rank-sum test for complex survey samples.

factors. Patients of each race or ethnicity other than White (including Black, Hispanic, and Asian/Pacific Islander patients) were more likely to suffer from high-risk PE, indicating increasing PE severity; yet, the use of advanced therapies was lower for such patients in the overall population and in high-risk PE. Compared with patients of the White race with high-risk PE, all other races with high-risk PE had greater in-hospital mortality. Insurance coverage by Medicaid has eligibility criteria that indicate lower socioeconomic status and was strongly associated with a reduced likelihood of receiving treatment with advanced therapies. In addition, belonging to the lowest quartile of income according to the zip code was significantly associated with higher in-hospital mortality.

There is increasing recent research on the association of minoritized communities with worse clinical outcomes in VTE, and PE in particular. Epidemiological data from the US show that mortality rates related to PE were consistently higher among the Black population during the last 20 years, with an almost two-fold difference compared with White people [8]. The higher hospitalization rates in Black patients than in White patients that we observed in this national US sample are in line with the findings of a previous study based on administrative, visit-level data from the state of Illinois [12]. In addition, the hospitalization rates for Asian/Pacific Islander and Hispanic patients were lower than those of White patients; this finding is in line with known racial differences in VTE incidence but may also reflect barriers to health care access [13]. In another US study of 10,329 hospitalizations, Phillips et al. [14] showed that Black persons had greater odds for higher PE severity, while also being less likely to receive a catheter-directed or surgical intervention; however, in-hospital mortality rates did not differ [14]. These findings are in accordance with our findings of the low use of advanced therapies and no apparent difference in in-hospital mortality rates among Black and White patients in the overall population. However, the effect estimate for mortality in high-risk PE was higher for non-White (Black, Hispanic, and Asian/Pacific Islander) patients and especially high for Asian/Pacific Islander patients, although the factors that influence the association with increased mortality are not clear. Douce et al. [15] showed in a national sample that outpatient treatment for DVT was half as frequent in Black compared with White participants, which could be due to social determinants in access to this care. Although there are biologic differences pertaining to VTE among discrete races, such as greater levels in various hemostatic and endothelial markers (including factor VIII, von Willebrand factor, plasmin antiplasmin, and D-dimer) in Black patients [16], it is possible that factors accompanying policies reflecting structural racism explain part of our findings, including residential and school segregation. Supporting this, in a study of patients with myocardial infarction (all with the same health insurance), no significant difference in mortality was observed among Black compared with White patients from well-resourced neighborhoods; however, Black Americans from disadvantaged neighborhoods had higher mortality than White Americans [17]. Altogether, our findings suggest racial and ethnic disparities in the management of acute PE and the access to advanced treatment modalities. These

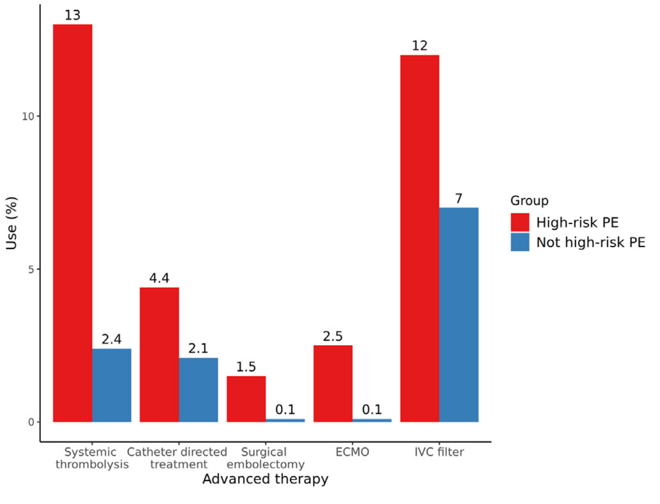

FIGURE 2 Use of advanced therapies according to the presence of high-risk PE. ECMO, extracorporeal membrane oxygenation; IVC, inferior vena cava; and PE, pulmonary embolism.

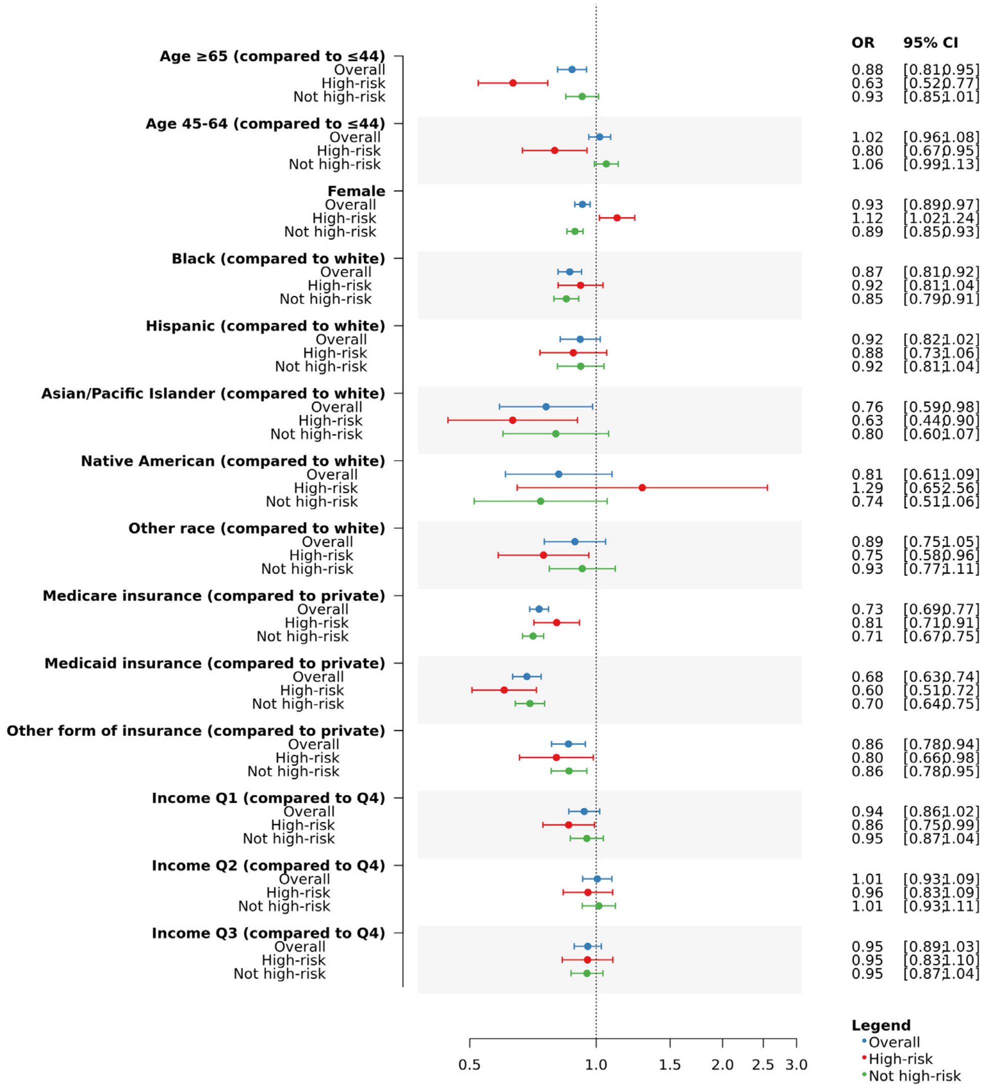

FIGURE 3 Multivariable logistic regression for the use of advanced therapies in hospitalized patients, overall, and in the subgroup of patients with high-risk and no high-risk acute pulmonary embolism (PE). The model is adjusted for high-risk PE, primary PE hospitalization, place of residence, hospital location/teaching status, hospital bed size, hypertension, diabetes mellitus, myocardial infarction, cerebrovascular disease, congestive heart failure, renal disease, chronic pulmonary disease, cancer, and dementia. The *x-axis* is plotted on a natural logarithmic scale. PE, pulmonary embolism.

findings are in line with previous data that report persistent differences between racial/ethnic groups in health care access, utilization, and affordability measures [18]. However, whether the results may also be driven by provider discretion cannot be excluded.

There is limited previous data on the influence of socioeconomic disadvantages on short- and long-term outcomes of PE. A recent study among older adults hospitalized for PE in the US showed that the socioeconomically disadvantaged patients received advanced therapy less often, and although they did not have greater in-hospital mortality, they had greater 1-year mortality and 30-day readmission rates [19]. In our study, patients with Medicaid insurance were less likely to undergo advanced therapies, even after adjusting for variables including the bed size or the location/teaching status of the hospital. Furthermore, there was a significant association between belonging to the lowest household income (based on zip codes) and increased in-hospital mortality, but also a non-significant trend between Medicaid insurance coverage and increased in-hospital mortality. In addition, we observed a much greater length of stay and cost of hospitalization for Medicaid patients; this suggests a hypothesis that reducing economic disparities may decrease the overall costs for the health care system.

These findings are not unique to PE. In addition, in the setting of myocardial infarction demographics, race and socioeconomic disparities have been linked to reduced access to invasive procedures and worse clinical outcomes [20,21]. However, the results of our study may raise awareness at a time when major clinical trials of

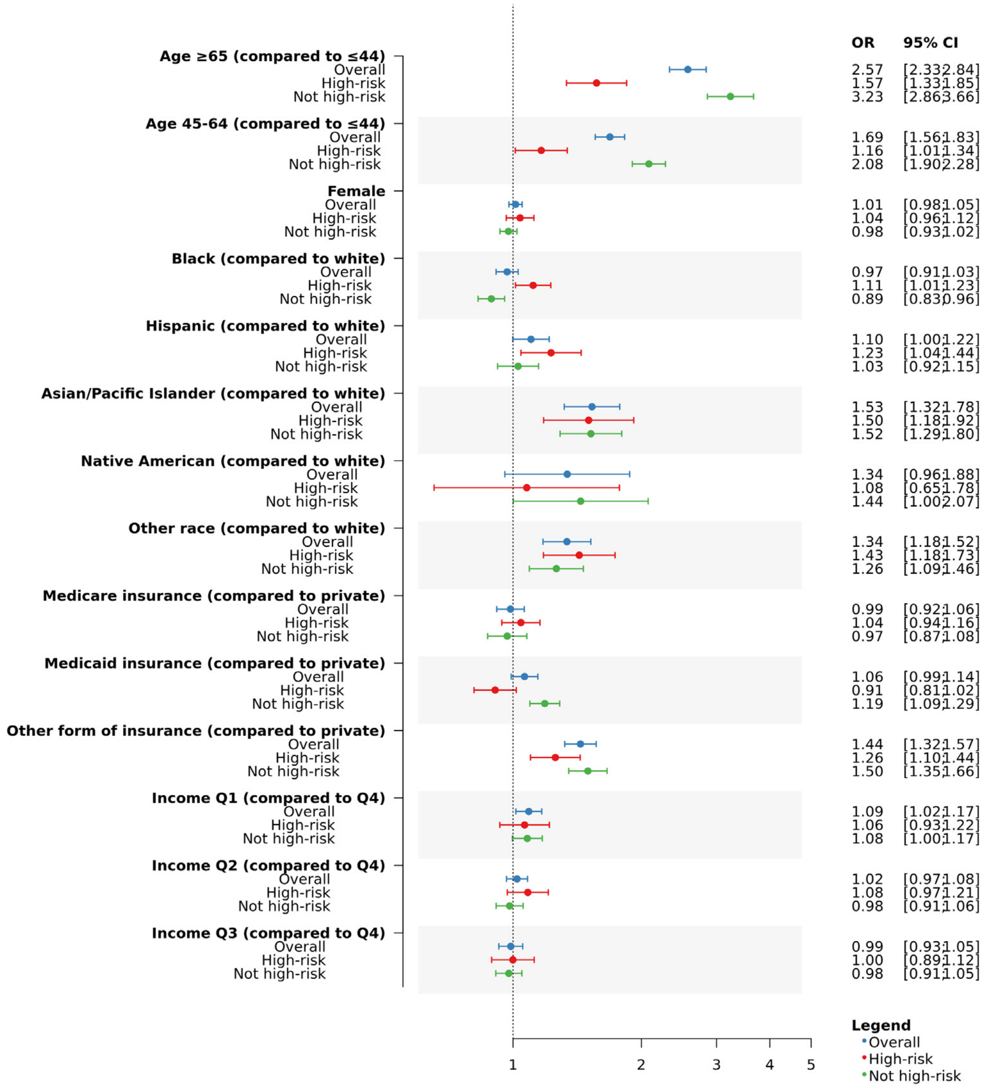

FIGURE 4 Multivariable logistic regression for in-hospital mortality, overall, and in the subgroup of patients with high-risk and no high-risk acute pulmonary embolism (PE). The model is adjusted for high-risk PE, primary PE hospitalization, use of any advanced therapy, place of residence, hospital location/teaching status, hospital bed size, hypertension, diabetes mellitus, myocardial infarction, cerebrovascular disease, congestive heart failure, renal disease, chronic pulmonary disease, cancer, and dementia. The *x-axis* is plotted on a natural logarithmic scale. PE, pulmonary embolism.

catheter-directed therapies are currently being designed and conducted for the management of acute PE and which are likely to increase their—already increasing [22]—use on a much wider scale. Our findings indicate that the delivery of clinically appropriate care to more disadvantaged populations may be disproportionately poor; although we used retrospective data that cannot be used to infer causality, our analysis suggests that it cannot be excluded that this disproportion may translate into clinical outcomes. The associations of the different factors (race, insurance coverage, income) with less advanced therapy use and worse fatality were independent of each other, suggesting that these factors act synergistically, i.e., the more factors an individual has the more likely they are to show a worse outcome.

4.1 | Limitations

This study evaluated administrative data and is subject to the limitations of this source of evidence. The study is observational, so no causal inferences are possible; the interpretation of the results is hypothesis-generating. We were not able to investigate more nuanced social determinants of health, such as the neighborhood area deprivation index, which has been linked to worse health outcomes in other cardiopulmonary diseases [23]. The patient's environment and the local availability of health care resources play a major role in the management of acute diseases, including PE, as not all management algorithms can be extrapolated in all settings [24]. Other factors, such as disease tolerance and psychosocial factors, may also delay the care

TABLE 3 Multivariable linear regression models for factors associated with length of stay and total charges in hospitalized acute pulmonary embolism.

Predictors	Length of stay Estimates (d)	Total charges Estimates (US $)
Age ≤44	Reference	Reference
Age 45-64	−0.69 (−0.90; −0.48)	−5,291 (-7,954; -2,629)
Age ≥65	−1.12 (−1.43; −0.81)	−13,863 (−18,352; −9,374)
Male	Reference	Reference
Female	−0.29 (−0.38; −0.19)	−8,046 (−10,188; −5,904)
White	Reference	Reference
Black	0.05 (−0.08; 0.18)	−3,852 (−8,112; 407)
Hispanic	0.17 (-0.07; 0.43)	21,395 (14,612; 28,179)
Asian/Pacific Islander	0.62 (0.12; 1.13)	26,773 (16,403; 37,143)
Native American	0.37 (−0.44; 1.21)	−2,220 (−14,916; 10,476)
Other race	0.75 (0.11; 1.39)	20,120 (6,678; 33,562)
Private Insurance	Reference	Reference
Medicare	0.56 (0.43; 0.70)	2,875 (224; 5,526)
Medicaid	1.92 (1.62; 2.23)	12,608 (9,095; 16,121)
Other insurance	1.39 (1.17; 1.62)	5,119 (1,347; 8,891)
Higher household income quartile (Q4)	Reference	Reference
Lowest household income quartile (Q1)	0.23 (0.07; 0.40)	−4,185 (−11,639; 3,269)
Household income quartile Q2	0.05 (−0.08; 0.19)	−4,023 (−10,379; 2,331)
Household income quartile Q3	−0.00 (−0.12; 0.11)	−4,461 (−9,642; 720)

The model is adjusted for all variables listed in the table plus high-risk PE, primary diagnosis of PE in the hospitalization, use of any advanced therapy, place of residence, hospital location/teaching status, hospital bed size, hypertension, diabetes mellitus, myocardial infarction, cerebrovascular disease, congestive heart failure, renal disease, chronic pulmonary disease, cancer, and dementia. 95% confidence interval in brackets.

PE, pulmonary embolism.

of an acute disease and affect the clinical outcomes, and these could vary by race or socioeconomic status [25]. In addition, socioeconomic status comprises more parameters than household income, such as individual education and occupation, which we were not able to capture and may influence clinical outcomes. We used median income in each patient's zip code, which might misclassify their individual household income, leading to an underestimation of associations. The interrelatedness of the studied social determinants of health is complex, and we cannot, based on these data, evaluate with certainty which of the parameters has a greater impact on access to the cure and clinical outcomes. This is particularly the case if one considers that several other determinants of health, notably education quality and level, and demographic variables were not available for analysis. However, we hypothesize that they each act independently. The classification of comorbidities and the use of advanced therapies were defined according to ICD-10 codes; therefore, misclassification is likely. We were also not able to classify patients with PE into typical risk stratification groups, such as low and intermediate risk, except for the high-risk subgroup. That said, we cannot be sure that the factors defining high risk were present before or after the PE. Finally, although advanced therapy use, and especially catheter-directed treatment, has not been proven to date to improve outcomes in patients without high-risk PE and they are not generally fully indicated by current guidelines, we cannot ascertain their contributing prognostic role and only regarding the use of it as a quality of care indicator [26,27].

5 | CONCLUSION

This investigation highlights disparities in the in-hospital management of PE according to several social determinants of health. Race/ethnicity other than White and low socioeconomic status measures were associated with reduced use of advanced treatment modalities, such as thrombolysis or catheter-directed interventions. Race/ethnicity other than White was not associated with greater in-hospital mortality, except in those with high-risk PE. Low socioeconomic status was associated with higher in-hospital mortality rates. Future studies should investigate whether there is a causal relationship between socioeconomic status and in-hospital outcomes, further investigate the long-term impact of social inequities, make an effort to recruit broadly across race/ethnicity and socioeconomic status and explore ways to mitigate the burden imposed by PE and its complications in minority populations.

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AUTHOR CONTRIBUTIONS

I.T.F., L.V., S.V.K., and S.B. contributed to the conception or design of this work. I.T.F. and L.V. contributed to the acquisition, analysis, or interpretation of data for the work. I.T.F., L.V., and S.B. drafted the manuscript. G.G., L.H., M.C., G.P., and S.V.K. critically revised the manuscript. All gave final approval and agreed to be accountable for all aspects of work, ensuring integrity and accuracy.

RELATIONSHIP DISCLOSURE

G.G. reports lecture/consultant fees from Bayer HealthCare, Pfizer, and LeoPharma. L.H. received lecture/consultant fees from MSD and Actelion, outside the submitted work. G.P. has received research support from Bristol-Myers Squibb/Pfizer Alliance, Bayer, Janssen, Alexion, Amgen, and Boston Scientific Corporation, and consulting fees from Bristol-Myers Squibb/Pfizer Alliance, Boston Scientific Corporation, Janssen, Namsa, Prairie Education and Research Cooperative, Boston Clinical Research Institute, and Amgen. S.V.K. reports institutional grants and personal lecture/advisory fees from Bayer AG, Daiichi Sankyo, and Boston Scientific; institutional grants from Inari Medica, and personal lecture/advisory fees from MSD and Bristol-Myers Squibb/Pfizer. S.B. received lecture/consultant fees from Bayer HealthCare, Concept Medical, BTG Pharmaceuticals, INARI, Boston Scientific, and LeoPharma; institutional grants from Boston Scientific, Bentley, Bayer HealthCare, INARI, Medtronic, Concept Medical, Bard, and Sanofi, and economical support for travel/congress costs from Daiichi Sankyo, BTG Pharmaceuticals, and Bayer HealthCare, outside the submitted work. The rest of the authors report no conflicts of interest.

INFORMED PATIENT CONSENT

Not applicable.

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SUPPLEMENTARY MATERIAL

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