Resuscitation Plus 20 (2024) 100777

Contents lists available at ScienceDirect

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Short paper

Utilization of inpatient palliative care services in cardiac arrest complicating acute pulmonary embolism

Aryan Mehta[a,1], Mridul Bansal[b,1], Chirag Mehta[c], Ashwin A. Pillai[a], Salman Allana[d], Jacob C. Jentzer[e], Corey E. Ventetuolo[f], J. Dawn Abbott[g,h], Saraschandra Vallabhajosyula[g,h,*]

[a] *Department of Medicine, University of Connecticut School of Medicine, Farmington, CT, United States*
[b] *Department of Medicine, East Carolina University Brody School of Medicine, Greenville, NC, United States*
[c] *Department of Medicine, Warren Alpert Medical School of Brown University, Providence, RI, United States*
[d] *Division of Cardiovascular Medicine, Department of Medicine, University of Texas Southwestern Medical School, Dallas, TX, United States*
[e] *Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN, United States*
[f] *Division of Pulmonary Critical Care and Sleep Medicine, Department of Medicine, Warren Alpert Medical School of Brown University, Providence, RI, United States*
[g] *Division of Cardiology, Department of Medicine, Warren Alpert Medical School of Brown University, Providence, RI, United States*
[h] *Lifespan Cardiovascular Institute, Providence, RI, United States*

A R T I C L E I N F O

Keywords:
Pulmonary embolism
Cardiac arrest
Palliative care services
Resource utilization
Critical care cardiology

A B S T R A C T

Introduction: The role of palliative care services in patients with cardiac arrest complicating acute pulmonary embolism has been infrequently studied.
Methods: All adult admissions with pulmonary embolism complicating cardiac arrest were identified using the National Inpatient Sample (2016–2020). The primary outcome of interest was the utilization of palliative care services. Secondary outcomes included predictors of palliative care utilization and its association of with in-hospital mortality, do-not-resuscitate status, discharge disposition, length of stay, and total hospital charges. Multivariable regression analysis was used to adjust for confounding.
Results: Between 01/01/2016 and 12/31/2020, of the 7,320 admissions with pulmonary embolism complicating cardiac arrest, 1229 (16.8 %) received palliative care services. Admissions receiving palliative care were on average older (68.1 ± 0.9 vs. 63.2 ± 0.4 years) and with higher baseline comorbidity (Elixhauser index 6.3 ± 0.1 vs 5.6 ± 0.6) (all $p < 0.001$). Additionally, this cohort had higher rates of non-cardiac organ failure (respiratory, renal, hepatic, and neurological) and invasive mechanical ventilation (all $p < 0.05$). Catheter-directed therapy was used less frequently in the cohort receiving palliative care, (2.8 % vs 7.9 %; $p < 0.001$) whereas the rates of systemic thrombolysis, mechanical and surgical thrombectomy were comparable. The cohort receiving palliative care services had higher in-hospital mortality (85.7 % vs. 69.1 %; adjusted odds ratio 2.20 [95 % CI 1.41–3.42]; $p < 0.001$). This cohort also had higher rates of do-not-resuscitate status and fewer discharges to home, but comparable hospitalization costs and length of hospital stay.
Conclusions: Palliative care services are used in only 16.8 % of admissions with cardiac arrest complicating pulmonary embolism with significant differences in the populations, suggestive of selective consultation.

Introduction

After myocardial infarction and stroke, acute pulmonary embolism (PE) is the third most common cardiovascular cause of death in the United States with 60,000–100,000 deaths per year.[1–3] PE accounts for 2–9 % of all out-of-hospital CA and 5–6 % of all in-hospital CA.[4–6] Approximately 70 % of the deaths following CA secondary to PE occur in the first hour.[7] The surviving patient population has a poor quality of life with multiple readmissions and hence can benefit significantly from the utilization of palliative care services (PCS).[8] In acutely ill patients, PCS

Abbreviations: CA, cardiac arrest; HCUP, healthcare cost and utilization project; NIS, national inpatient sample; PCS, palliative care services; PE, pulmonary embolism.

* Corresponding author at: Warren Alpert Medical School of Brown University, 2 Dudley Street, Suite 360, Providence, RI 02905, United States.
E-mail address: svallabhajosyula@lifespan.org (S. Vallabhajosyula).

[1] contributed equally as co-first authors.

https://doi.org/10.1016/j.resplu.2024.100777
Received 12 June 2024; Received in revised form 2 September 2024; Accepted 6 September 2024

are intended to improve the quality of life of the patient and their families by providing psychosocial and spiritual support.[9] Within cardiovascular medicine, a majority of the published literature has focused on PCS use in patients with acute decompensated heart failure with limited data available for other acute conditions.[8,10–13] The utilization and predictors of PCS in patients with PE who present with CA are not fully elucidated. Through this study, we sought to evaluate the rates of use and predictors of PCS in admissions with PE with CA.

Methodology

Study population

The National (Nationwide) Inpatient Sample (NIS) is the largest publicly available all-payer inpatient database designed by the Agency for Healthcare Research and Quality (AHRQ) for the Healthcare Cost and Utilization Project (HCUP).[14] This database contains data from 7 million hospital stays each year which when weighted contains data from an estimated 35 million hospitalizations annually.[14] No Institutional review board was sought due to the database being publicly available and having deidentified patient information.

The 2016–2020 database was used for this retrospective analysis with adult (≥18 years) PE admissions as a primary diagnosis field. International Classification of Diseases, Tenth Revision, Clinical Modification codes (ICD-10-CM) I2601, I2602, I2609, I2690, I2692, I2693, I2694, and I2699 were used to identify admissions with PE.[15–16] A secondary diagnosis of CA was identified using ICD-10-CM codes I460, I461, I462, I468, I469, I490, I4901, and 5A12012. Both out-of-hospital and in-hospital CA were considered together due to poor discrimination based on administrative codes.[17–18] The utilization of PCS was identified using ICD-10-CM code Z51.5.[13] The validation studies for PCS utilization using ICD-9-CM code V66.7 have demonstrated moderate sensitivity and high specificity (>90 %). They have noted that when the ICD-9-CM code V66.7 is documented, >90 % inpatient admissions receive PCS consultation.[19–20] There is a lack of similar validation studies for ICD-10 CM code Z51.5 with one study reporting under-representation of inpatient PCS utilization using this ICD-10-CM code.[21] Patient characteristics including age, race, sex, disease burden using Elixhauser Comorbidity Index, median household income for zip codes reported by national quartiles, primary payer, hospital region, hospital bed size, location, and teaching status were included. Acute organ failure and complications, utilization of non-cardiovascular organ support, cardiovascular procedures, and medications including vasopressors, were identified using previously elucidated methodology from our group (Supplementary Table 1).[22–23]

The primary outcome of interest was the inpatient use of PCS in PE with CA. Secondary outcomes included predictors of PCS utilization and association of PCS utilization with in-hospital mortality, do-not-resuscitate (DNR) status, discharge disposition, length of stay, and total hospital charges.

Statistical analysis

As recommended by HCUP-NIS, admissions were weighted using discharge-level weights to estimate national estimates of PE admissions.[14] Consistent with HCUP-NIS best practices, the details regarding admissions were limited to inpatient factors since NIS does not cover outpatient data and only those administrative codes which had been validated by previous similar studies were used.[24] All encounters were treated as hospitalizations rather than individual patients, since the HCUP-NIS does not track readmissions on the same patient.[24] Continuous variables were evaluated using a *t*-test and categorical variables using a chi-square test. A multivariable regression analysis adjusting for relevant variables was performed for in-hospital mortality and an odds ratio (OR) with 95 % confidence intervals (CI) was used to represent the data. For inclusion in multivariable modeling, regression analysis with a threshold of $p < 0.20$ in the univariate analysis of clinically relevant variables was performed. Statistical significance was determined by a two-tailed $p < 0.05$. All statistical analyses were performed using STATA 16.0 software (StataCorp LLC, College Station TX).

Table 1
Baseline and in-hospital characteristics of pulmonary embolism admissions with cardiac arrest.

Baseline characteristics	Palliative care (N=1,229)	No palliative care (N=6,091)	*P*
Age	68.1 ± 0.88	63.2 ± 0.42	<0.001
Race			
• *White*	746(60.7 %)	3495(57.4 %)	0.34
• *Black*	313(25.5 %)	1675(27.5 %)	0.52
• *Hispanic*	59(4.8 %)	451(7.4 %)	0.15
• *Asian*	29(2.4 %)	97(1.6 %)	0.39
• *Native American*	0	18(0.3 %)	0.36
• *Others*	34(2.8 %)	171(2.8 %)	0.96
• *Missing*	49(4 %)	195(3.2 %)	0.57
Females	691(56.2 %)	3228(53 %)	0.35
Elixhauser Index	6.3 ± 0.12	5.6 ± 0.6	<0.001
Household income national quartile			0.03
• *0-25th*	340(27.7 %)	2015(33.1 %)	
• *25-50th*	371(30.2 %)	1480(24.3 %)	
• *50-75th*	246(20 %)	1505(24.7 %)	
• *75-100th*	270(22 %)	1078(17.7 %)	
Primary payer			<0.01
• *Medicare*	775(63.1 %)	3087(50.7 %)	
• *Medicaid*	104(8.5 %)	743(12.2 %)	
• *Private*	248(20.2 %)	1765(29 %)	
• *Self-pay*	69(5.6 %)	329(5.4 %)	
• *No Charge*	–	–	
• *Others*	25(2 %)	158(2.6 %)	
Hospital region			0.57
• *Northeast*	198(16.1 %)	933(15.3 %)	
• *Midwest*	333(27.1 %)	1436(23.6 %)	
• *South*	448(36.4 %)	2490(40.9 %)	
• *West*	248(20.2 %)	1218(20 %)	
Hospital bed size			0.81
• *Small*	204(16.6 %)	907(14.9 %)	
• *Medium*	362(29.5 %)	1854(30.4 %)	
• *Large*	662(53.8 %)	3327(54.6 %)	
Hospital location/teaching status			0.62
• *Rural*	54(4.4 %)	262(4.3 %)	
• *Urban Non-teaching*	183(14.9 %)	1064(17.5 %)	
• *Urban teaching*	990(80.5 %)	4752(78 %)	
Acute organ failure and complications			
• *Renal failure*	775(63.1 %)	2950(48.5 %)	<0.001
• *Respiratory failure*	1078(87.8 %)	4694(76.9 %)	<0.001
• *Hepatic failure*	367(29.9 %)	1019(16.7 %)	<0.001
• *Hematologic failure*	343(27.9 %)	1356(22.2 %)	0.05
• *Neurologic failure*	765(62.3 %)	1894(31.1 %)	<0.001
Intracranial hemorrhage	34(2.8 %)	109(1.8 %)	0.34
Bleeding complications	233(19 %)	1161(19.1 %)	0.96
Non-cardiovascular organ support			
• *Non-invasive ventilation*	39(3.2 %)	426(7 %)	0.02
• *Invasive ventilation*	1134(92.3 %)	4592(75.5 %)	<0.001
• *Hemodialysis*	88(7.2 %)	305(5 %)	0.14
Cardiovascular procedures			
• *Catheter-directed therapy*	34(2.8 %)	481(7.9 %)	<0.01
• *Systemic thrombolysis*	432(35.2 %)	2164(35.6 %)	0.89
• *Mechanical thrombectomy*	59(4.8 %)	365(6 %)	0.46
• *Surgical thrombectomy*	20(1.6 %)	55(0.9 %)	0.30
• *Pulmonary artery catheterization*	10(0.8 %)	55(0.9 %)	0.79
Vasopressor use	358(29.1 %)	1402(23.1 %)	0.05

Represented as: N(%); Percentage or mean ± standard deviation

Results

Between January 1, 2016, and December 31, 2020, there were a total of 904,079 non-elective admissions with a primary diagnosis of PE, of which CA was present in 7,320 (0.8 %). Use of PCS was documented in 1,229 (16.8 %) admissions with CA complicating PE and in 3.6 %

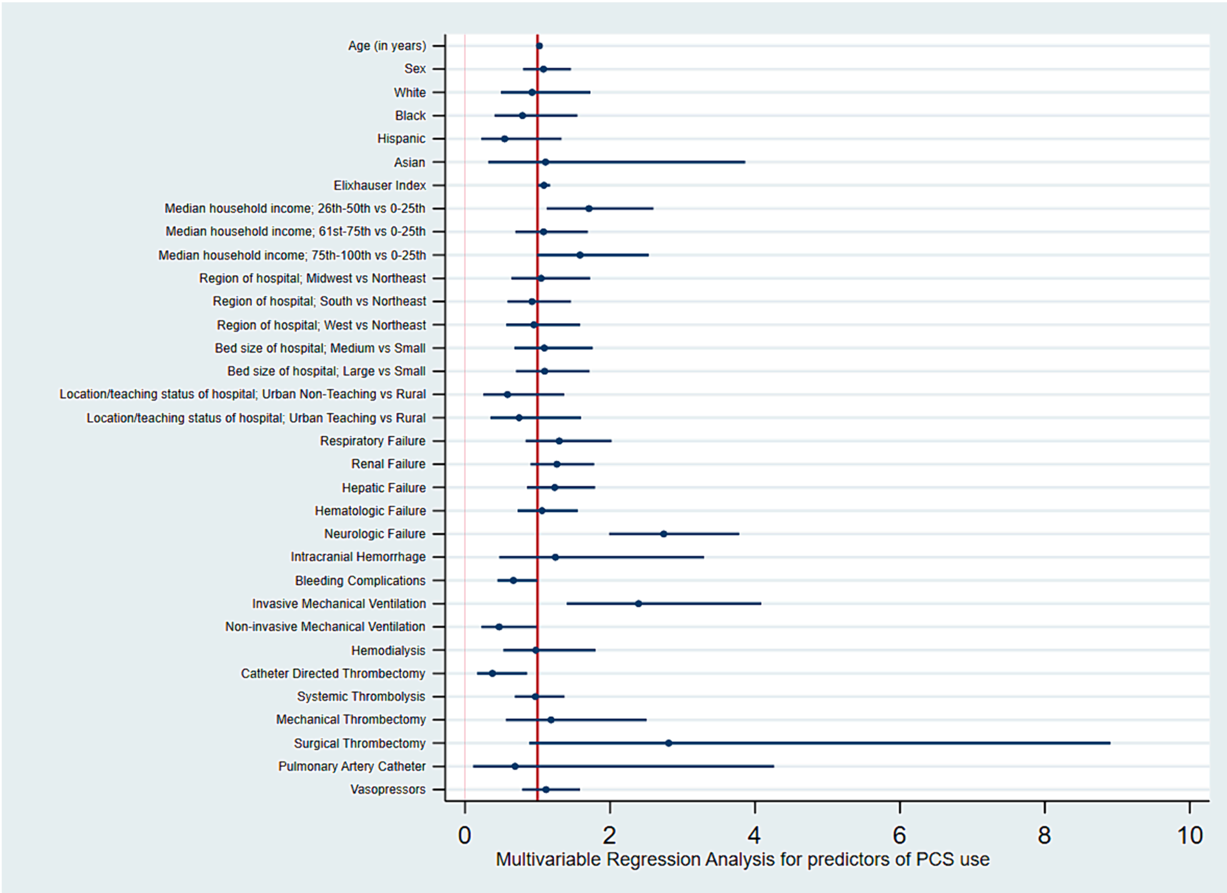

Fig. 1. Predictors of palliative care services utilization among admissions with cardiac arrest complicating pulmonary embolism. **Abbreviations:** PCS: palliative care services.

admissions with PE but not CA (unadjusted OR 5.35; 95 % CI 4.75–6.02; $p < 0.001$). Admissions who received PCS were on average older, with higher baseline comorbidity, and had Medicare as the primary payer (Table 1). The cohort receiving PCS had higher rates of non-cardiac organ failure including respiratory, renal, hepatic, and neurological failure, and higher rates of invasive mechanical ventilation (all $p < 0.05$) (Table 1). Catheter-directed therapy was used less commonly in the PCS cohort, whereas the rates of systemic thrombolysis, mechanical thrombectomy, surgical thrombectomy, and pulmonary artery catheterization were comparable. In a multivariable logistic regression, older age, a lower median household income, neurologic failure, and utilization of invasive mechanical ventilation were independently associated with PCS use (Fig. 1 and Supplementary Table 3**).**

A total of 5,260 (71.9 %) patients died during hospitalization. The PCS cohort had higher in-hospital mortality – 85.7 % vs. 69.1 %, unadjusted OR 2.69 (95 % CI 1.85–3.92); $p < 0.001$. After multivariable adjustment, the cohort receiving PCS continued to demonstrate higher in-hospital mortality (adjusted OR 2.20; 95 % CI 1.41–3.42; $p < 0.001$), as did patients who had a do-not-resuscitate status (Fig. 2 **and** Supplementary Table 2). The PCS cohort had higher rates of do-not-resuscitate status, and fewer discharges to home, but comparable hospitalization costs and length of hospital stay (Table 2).

Discussion

In this first national study exploring the utilization of PCS in PE complicated by CA, 16.8 % of admissions received PCS. Older age, lower household income, neurologic failure, and utilization of invasive mechanical ventilation were predictive of PCS utilization. The cohort receiving PCS had lower utilization of non-invasive mechanical ventilation and catheter-directed therapies, higher in-hospital mortality, more frequent use of do-not-resuscitate status, and fewer discharges to home.

PE presenting with hemodynamic instability is associated with a mortality rate of 30 % but is as high as 95 % in patients with CA.[25] Empiric treatment with thrombolytic therapy including recombinant tissue plasminogen activators has been recommended in the guidelines of multiple societies in cases where CA is suspected secondary to massive PE.[26] As noted in this study, around one-third of admissions (35.2 % in the PCS cohort and 35.6 % in the non-PCS cohort) received systemic thrombolysis. In patients with contraindications for thrombolytics, there have also been reports on the successful utilization of catheter-directed mechanical thrombectomy and surgical embolectomy in patients with concomitant PE and CA.[27].

There are only a small number of patients that survive CA and even fewer that have optimal quality of life. This surviving patient population has frequent interactions with the medical system and often have a poor quality of life and increased resource utilization with increased visits to health care facilities.[28] Consequently, this patient population can benefit significantly from increased utilization of PCS. Even though the utilization of PCS was significantly higher in admissions with PE and CA (16.8 %) when compared to PE without CA (3.6 %), the rate of PCS utilization remained low overall which is in accordance with prior observations in cardiovascular disease. This is partly in the setting of limited awareness of these services, lack of robust PCS training, and the stigma of end-of-life care associated with them leading to either delayed referral or no referral at all. In our study, despite being sicker at baseline, receiving similar interventions, and in some instances, requiring more

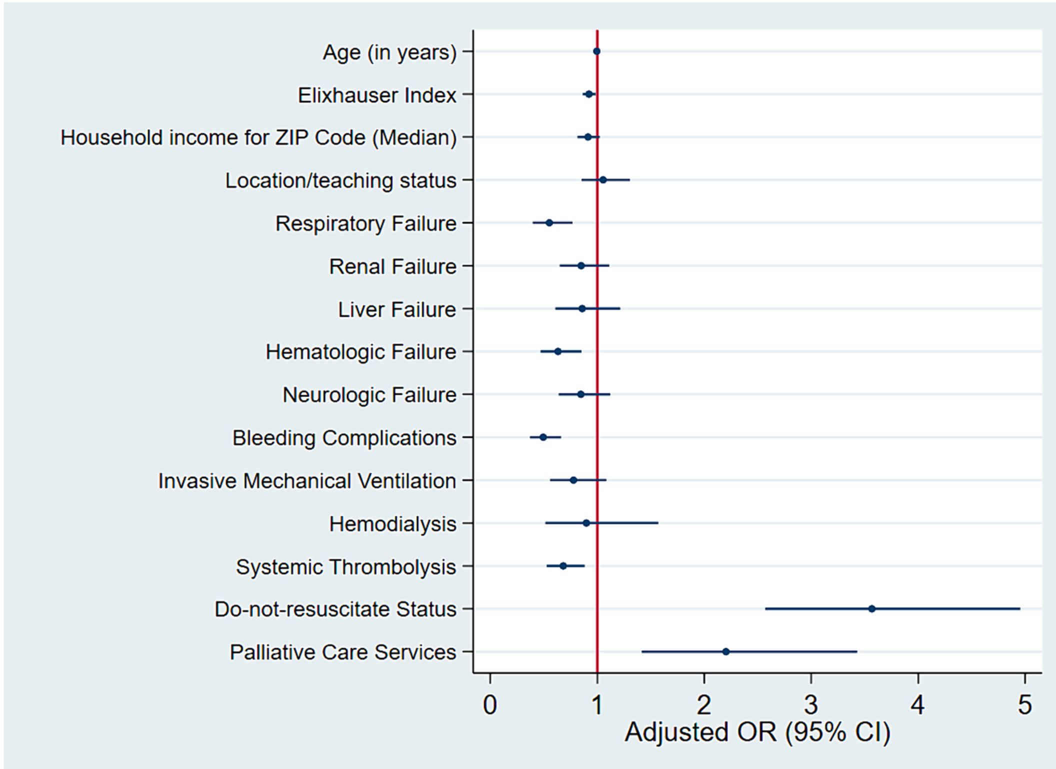

Fig. 2. In-hospital mortality in admissions with pulmonary embolism (PE) complicated by cardiac arrest (CA). Multivariable-adjusted odds ratio (95 % confidence interval) for in-hospital mortality adjusted for age, Elixhauser comorbidity index, household income, location/teaching status of the hospital, acute organ failure, non-cardiovascular organ support, cardiovascular procedures, do-not-resuscitate code status, and palliative care services. **Abbreviations:** CI: confidence interval; OR: odds ratio.

Table 2
Outcomes of pulmonary embolism admissions with cardiac arrest.

Outcomes	Palliative care (N = 1229)	No palliative care (N = 6091)	*P*
In-hospital mortality	1056(85.7 %)	4211(69.1 %)	<0.001
Do-not-resuscitate status	889(72.4 %)	1245(20.4 %)	<0.001
Discharge disposition			
• *Home (self-care)*	10(0.8 %)	451(7.4 %)	<0.001
• *Short-term hospital*	5(0.4 %)	305(5 %)	
• *Skilled nursing facility*	144(11.7 %)	810(13.3 %)	
• *Home health care*	15(1.2 %)	299(4.9 %)	
Length of stay in days	5 ± 0.51	5.7 ± 0.25	0.22
Total hospital charges (United States Dollars)	130175.1 ± 8573.4	128221.8 ± 4405.6	0.83

Represented as: N(%); Percentage or mean ± standard deviation.

intensive life-supportive measures, the costs and lengths of hospital stay in the PCS were comparable to the cohort that did not receive PCS.

Limitations

The study was done using a large administrative dataset and has limitations inherent to this database. The National Inpatient Sample identifies admissions based on the discharge diagnoses, exclusion of admissions having PE with CA and inclusion of admissions with other diagnoses is possible due to errors in coding. Admissions with out-of-hospital CA due to PE could have been coded to have a primary diagnosis of CA with a secondary diagnosis of PE and subsequently missed in our analysis. In addition, the timing and reason for PCS referral and the intervention done could not be assessed using this dataset. HCUP-NIS does not provide information regarding symptoms or severity of symptoms, computed tomographic scan findings, echocardiographic variables, angiographic data, and various hemodynamic parameters making it difficult to assess disease severity. Lastly, the ICD-10 CM code Z51.5 has not been extensively validated by prior studies. This can lead to misrepresentation of the data related to specific procedures and interventions leading to imprecise data analysis and interpretation.

Conclusions

In this large national analysis, PCS was used only in 16.8 % of admissions with CA complicating PE. Despite the high mortality associated with this disease process, there are perceived barriers to the utilization of PCS. Further descriptive studies evaluating the patient, provider, and hospital-specific barriers to PCS implementation are needed.

Author contributions

Study design, literature review, statistical analysis: AM, MB, CM, AAP, SV.
Data management, data analysis, drafting manuscript: AM, MB, CM, AAP, SV.
Manuscript revision, intellectual revisions, mentorship: SA, JCJ, JDA, SV.
Final approval: AM, MB, CM, AAP, SA, JCJ, JDA, SV.

Sources of funding

None.

CRediT authorship contribution statement

Aryan Mehta: Writing – original draft, Resources, Methodology, Investigation, Formal analysis, Data curation. **Mridul Bansal:** Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Chirag Mehta:** Writing – original draft, Software, Methodology, Data curation. **Ashwin A. Pillai:** Writing – original draft, Software, Resources, Methodology, Formal analysis, Data curation. **Salman Allana:** Writing – review & editing, Validation, Supervision, Software, Methodology, Data curation. **Jacob C. Jentzer:** Writing – review & editing, Validation, Resources, Project administration, Methodology, Funding acquisition, Formal analysis. **Corey E. Ventetuolo:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology. **J. Dawn Abbott:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation. **Saraschandra Vallabhajosyula:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Disclosures: JDA receives research funding from Boston Scientific, Shockwave, Med Alliance, and serves as a consultant for Abbott, Medtronic, Penumbra, Recor. All other authors do not report any relevant conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100777.

References

1. Benjamin EJ, Muntner P, Alonso A, et al. Heart Disease and Stroke Statistics-2019 Update: A Report From the American Heart Association. *Circulation*. 2019;139:e56–e528.
2. Morrone D, Morrone V. Acute pulmonary embolism: focus on the clinical picture. *Korean Circ J*. 2018;48:365–381.
3. Martin KA, Molsberry R, Cuttica MJ, Desai KR, Schimmel DR, Khan SS. Time trends in pulmonary embolism mortality rates in the United States, 1999 to 2018. *J Am Heart Assoc*. 2020;9:e016784.
4. Kürkciyan I, Meron G, Behringer W, et al. Accuracy and impact of presumed cause in patients with cardiac arrest. *Circulation*. 1998;98:766–771.
5. Pokorna M, Necas E, Skripsky R, Kratochvil J, Andrlik M, Franek O. How accurately can the aetiology of cardiac arrest be established in an out-of-hospital setting? Analysis by "concordance in diagnosis crosscheck tables". *Resuscitation*. 2011;82:391–397.
6. Soar J, Perkins GD, Maconochie I, et al. European resuscitation council guidelines for resuscitation: 2018 update – antiarrhythmic drugs for cardiac arrest. *Resuscitation*. 2019;134:99–103.
7. Silfvast T. Cause of death in unsuccessful prehospital resuscitation. *J Intern Med*. 1991;229:331–335.
8. Belur AD, Mehta A, Bansal M, et al. Palliative care in the cardiovascular intensive care unit: a systematic review of current literature. *Cardiovasc Revasc Med*. 2024.
9. Buss MK, Rock LK, McCarthy EP. Understanding palliative care and hospice: a review for primary care providers. *Mayo Clin Proc*. 2017;92:280–286.
10. Romano M. The role of palliative care in the cardiac intensive care unit. *Healthcare (Basel)*. 2019;7.
11. Kanwar A, Patlolla SH, Singh M, et al. Temporal trends, predictors and outcomes of inpatient palliative care use in cardiac arrest complicating acute myocardial infarction. *Resuscitation*. 2022;170:53–62.
12. Anand V, Vallabhajosyula S, Cheungpasitporn W, et al. Inpatient palliative care use in patients with pulmonary arterial hypertension: temporal trends, predictors, and outcomes. *Chest*. 2020;158:2568–2578.
13. Vallabhajosyula S, Prasad A, Dunlay SM, et al. Utilization of palliative care for cardiogenic shock complicating acute myocardial infarction: a 15-year national perspective on trends, disparities, predictors, and outcomes. *J Am Heart Assoc*. 2019;8:e011954.
14. Cost H, Project U. *Introduction to the HCUP National Inpatient Sample (NIS). The national (nationwide) inpatient sample database documentation*. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
15. Li S, Lio KU, Ho TA, Wang Y, Rali P. Effect of malnutrition on outcomes of hospitalisations for acute pulmonary embolism: a national inpatient database study. *BMJ Nutr Prev Health*. 2023;6:188–195.
16. Burles K, Innes G, Senior K, Lang E, McRae A. Limitations of pulmonary embolism ICD-10 codes in emergency department administrative data: let the buyer beware. *BMC Med Res Methodol*. 2017;17:89.
17. Vallabhajosyula S, Jentzer JC, Zack CJ. Cardiac arrest definition using administrative codes and outcomes in acute myocardial infarction. *Mayo Clin Proc*. 2020;95:611–613.
18. DeZorzi C, Boyle B, Qazi A, et al. Administrative billing codes for identifying patients with cardiac arrest. *J Am Coll Cardiol*. 2019;73:1598–1600.
19. Feder SL, Redeker NS, Jeon S, et al. Validation of the ICD-9 diagnostic code for palliative care in patients hospitalized with heart failure within the veterans health administration. *Am J Hosp Palliat Care*. 2018;35:959–965.
20. Hua M, Li G, Clancy C, Morrison RS, Wunsch H. Validation of the V66.7 Code for Palliative Care Consultation in a Single Academic Medical Center. *J Palliat Med*. 2017;20:372–377.
21. Stubbs JM, Assareh H, Achat HM, Greenaway S, Muruganantham P. Verification of administrative data to measure palliative care at terminal hospital stays. *Health Inform Manage J*. 2023;52:28–36.
22. Vallabhajosyula S, Barsness GW, Herrmann J, Anavekar NS, Gulati R, Prasad A. Comparison of complications and in-hospital mortality in takotsubo (apical ballooning/stress) cardiomyopathy versus acute myocardial infarction. *Am J Cardiol*. 2020;132:29–35.
23. Vallabhajosyula S, Dunlay SM, Prasad A, et al. Acute noncardiac organ failure in acute myocardial infarction with cardiogenic shock. *J Am Coll Cardiol*. 2019;73:1781–1791.
24. Khera R, Krumholz HM. With great power comes great responsibility: big data research from the national inpatient sample. *Circ Cardiovasc Qual Outcomes*. 2017:10.
25. Laher AE, Richards G. Cardiac arrest due to pulmonary embolism. *Indian Heart J*. 2018;70:731–735.
26. Böttiger BW, Böhrer H, Bach A, Motsch J, Martin E. Bolus injection of thrombolytic agents during cardiopulmonary resuscitation for massive pulmonary embolism. *Resuscitation*. 1994;28:45–54.
27. Meyer G, Tamisier D, Sors H, et al. Pulmonary embolectomy: a 20-year experience at one center. *Ann Thorac Surg*. 1991;51:232–236.
28. Thangavel S, Korsholm K, Veien KT, Larsen KM, Andersen A. Catheter-directed mechanical thrombectomy in a patient with high-risk pulmonary embolism complicated by out-of-hospital cardiac arrest: a case report. *Eur Heart J Case Rep*. 2023;7:ytad307.