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Clinical paper

Incidence, predictors, causes, and costs of 30-day readmission after in-hospital cardiopulmonary resuscitation in the United States

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Abstract

Background: Readmissions after in-hospital cardiopulmonary resuscitation (ICPR) are common and contribute to increased health care utilization and costs. This study aimed to estimate the burden and patterns of 30-day readmission after ICPR from the US Nationwide Readmission Database (NRD).

Methods: Using International Classification of Diseases-Ninth Revision-Clinical Modification codes, patients who underwent ICPR in the 2014 NRD were included. The incidence, predictors, causes, and costs of 30-day readmission were analyzed with discharge weights to obtain national estimates.

Results: Among the 27,278 index admissions that survived to hospital discharge after ICPR, 5439 (20.0%) were readmitted within 30 days. Length of stay (LOS) ≥11 days during index hospitalization, chronic pulmonary disease, congestive heart failure, renal failure, discharge from the teaching metropolitan hospital, Medicare insurance, depression, and diabetes were independent predictors of 30-day readmission. The most common causes of readmission among the 5439 cases were sepsis (13.7%), heart failure (10.9%), and respiratory failure (6.4%). The estimated median costs of readmission were $10,498 (interquartile range, $5797–21,364), which accounted for 25.7% of the total episodes of care (index + readmission). The median LOS of readmission was 5 (3–9) days.

Conclusions: Thirty-day readmissions after ICPR were associated with patient comorbidities and significant cost burden. Recognition of these predictors and individualization of care would allow for the provision of appropriate interventions, and reduce readmissions and healthcare costs.

Keywords: Readmission, Cardiopulmonary resuscitation, Cost, Predictors

Introduction

Almost 200,000 patients undergo in-hospital cardiopulmonary resuscitation (ICPR) for in-hospital cardiac arrest (IHCA) in the United States (US) annually.[1] The national incidence of ICPR is approximately 1.81–2.37 per 1000 admission. The reported rate of patients who survived to discharge after ICPR varies from 17% to 33%.[2–5] Although considerable efforts have been focused on improving the mortality and morbidity rates in ICPR survivors, only a few studies have examined ICPR-related readmissions. A previous study based on GWTG-resuscitation, which was the large prospective registry of ICPR including 523 acute-care hospitals, reported a high rate of readmissions and high follow-up inpatient costs among survivors of ICPR, with the 30-day readmission, 1-year readmission, and 1-year mortality rates being 35%,[6] 66%, and 41%,[7] respectively.

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Additionally, to our knowledge, no study has systemically analyzed factors at the patient/hospital level independently associated with early readmissions after ICPR discharge using a national cohort. The lack of information on key determinants of short-term readmission prevents patients and clinicians from understanding expected outcomes after recovery. The recognition of different standards of care among hospitals has led to efforts to improve patient outcomes and optimize the quality of care. Consequently, the main purpose of this study was to identify the incidence, predictors, causes, and costs of 30-day readmission after ICPR using a nationally representative database in the US.

Methods

Study cohort

We retrospectively investigated a cohort of patients from the 2014 Nationwide Readmissions Database (NRD), which is a database containing all-payer hospital inpatient information, constructed from the Healthcare Costs and Utilization Project's (HCUP) State Inpatient Database (SID). Twenty-two states contributed to the 2014 NRD. These included states accounted for 51.2% of the total US population and for 49.3% of all US hospitalizations. The NRD includes data on all inpatient discharges of community hospitals, excluding rehabilitation or long-term acute care hospitals. Discharges with missing patient linkage numbers or documentation errors were excluded according to the NRD methodology. Weights of discharge can be used to calculate national estimates. After exclusion, the 2014 NRD constitutes approximately 15 million discharges (unweighted), and estimates approximately 35 million discharges (weighted) in the US.[8]

Institutional review board approval and informed consent for the current study was waived given the nature of the NRD as a publicly available database, with the absence of any personal information.

Identification of ICPR index admissions and unplanned 30-day readmissions

The NRD contains data on patient and hospital characteristics essential to readmission analysis. Verified patient linkage number (NRD_VisitLink) can be used to identify discharges linked to the same individual. We calculated the days between each discharge and subsequent readmissions using a timing variable (NRD_DaysToEvent). We included all index ICPR cases discharged from January 1, 2014 through November 2014 with International Classification of Diseases-Ninth Revision-Clinical Modification (ICD9-CM) procedural codes 99.60 (cardiopulmonary resuscitation) and 99.63 (closed chest massage), which were previously used to identify ICPR cases in the similar studies.[2,3,9,10] We did not use ICD9-CM diagnosis codes 427.41 (ventricular fibrillation [VF]), 427.42 (ventricular flutter), or 427.5 (cardiac arrest) to identify index ICPR cases because these codes may be also used in patients who were at out-of-hospital cardiac arrest or IHCA with do-not-resuscitate when analyzing NRD. We excluded the cases aged <18 years, with a length of stay (LOS) > 180 days, those who died during their hospital stay, those who transferred to a rehabilitation hospital, and non-state residents. We identified all unplanned readmissions within 30 days of index discharges. If there were multiple readmissions for each index case, we only included the first readmission in order independently to analyze the factors associated with unplanned readmission after ICPR.

Patient and hospital characteristics

The Elixhauser comorbidity software was used to identify 29 Elixhauser comorbiditiy variables and we implemented numeric score using ICD9-CM diagnosis codes and diagnosis-related groups (DRG), which allowed for the evaluation of the burden of patient comorbidities.[11] Patients were given a score <3 or ≥3 on the basis of the number of comorbidities. We identified shockable rhythms at ICPR using ICD9-CM codes 427.41 (VF), 427.42 (ventricular flutter), or 427.1 (ventricular tachycardia [VT]). Without any of the indicated codes, the rhythms of the index admission were considered to be non-shockable rhythms (asystole or pulseless electrical activity).[2,10] The causes of admission and in-hospital procedures were identified using Clinical Classifications Software (CCS) for ICD-9-CM, allowing for the collapse of diagnostic and procedural codes into clinically relevant categories.[12]

Outcomes measured and statistical analysis

The primary outcome of this study was the overall rate of unplanned binary 30-day readmission after ICPR. All analyses were performed and presented as weighted data. The proportion of ICPR index admissions and subsequent readmissions were first identified. Subsequently, we evaluated the causes and costs for index admissions and 30-day readmissions. Patient characteristics for the 30-day readmission were assessed using the Chi-squared test, Student's t test, and Wilcoxon rank-sum test, for categorical variables, normally distributed continuous variables, and non-normally distributed continuous variables, respectively. P values were reported without multiple testing adjustment and values <0.01 were considered to be statistically significant. The Shapiro–Wilk normality test was used to assess the normality of the distribution of continuous variables. Categorical variables were expressed as percentages and continuous variables as mean ± standard deviation (SD) or median (interquartile range [IQR]) as appropriate. Cox proportional hazards regression analysis was used to identify the predictors of 30-day readmission. The elapsed time to readmission was used for the Cox model. Specifically, clinically meaningful patient/hospital characteristics with a p-value of < 0.05 on univariate analysis were entered into a multivariate model to identify independent predictors of 30-day readmission. Hazard ratios (HR) and 95% confidence intervals (CI) were used to report the results of the Cox regression analyses. Kaplan-Meier curves were plotted using the proportions of 30-day readmission stratified by independent predictors.

Data were complete for all variables except primary expected payer (9 [0.069%] missing) and median household income for patient's ZIP code (182 [1.4%] missing). Since the missing values were minimal, these were replaced with the dominant category for these variables. Cost analysis was based on data for index hospitalizations and readmissions excluding missing values, with 428 (3.3%) and 82 (3.2%) were missing, respectively.

All null hypotheses were evaluated using 2-sided tests. All analyses were performed using R 3.4.1 (R Foundation for Statistical Computing). Survey R package was used to analyze the weighted database.[13]

Results

Study cohort

The median age of all patients was 66 (55–76) years, and 43.7% of the cohort were women. The overall incidence of ICPR was 3.39 per 1000 hospitalizations. Of the 119,558 admitted patients who underwent ICPR, 37,014 (31.0%) survived to hospital discharge and 82,544 (69.0%) died in the hospital. After applying the exclusion criteria, the final cohort included 27,278 index admissions who survived to hospital discharges after ICPR; of these 5439 (20.0%) were readmitted within 30 days (Figure S1). We identified 6273 (23.0%) multiple readmissions per all of the index cases enrolled. The primary diagnosis of the final cohort included sepsis (13.9%), acute myocardial infarction (11.9%), respiratory failure (9.3%), dysrhythmia (5.2%), and congestive heart failure (4.6%) (Table S1). Shockable arrest rhythms were identified in 8347 (30.6%) discharged patients.

Baseline characteristics and independent predictors of 30-day readmission

Compared with patients who were not readmitted within 30 days, those readmitted stayed for a greater number of days during the index hospitalization, had Medicare insurance, were discharged to home health care, were transferred to a skilled nursing facility (SNF)/ intermediate care facility, had $\geq$4 Elixhauser comorbidities, and were discharged from the metropolitan teaching hospital. Patients who were readmitted within 30 days were more likely to have undergone mechanical ventilation, vascular catheterization, blood transfusion, and hemodialysis (Table 1). On multivariate analysis, LOS $\geq$11 days during index hospitalization (HR, 1.43; 95% CI, 1.30–1.58), chronic pulmonary disease (HR, 1.21; 95% CI, 1.09–1.34), congestive heart failure (HR, 1.19; 95% CI, 1.07–1.32), renal failure (HR, 1.19; 95% CI, 1.06–1.34), discharge from teaching metropolitan hospital (HR, 1.16; 95% CI, 1.04–1.29), Medicare insurance (HR, 1.15; 95% CI, 1.04–1.27), depression (HR, 1.18; 95% CI, 1.01–1.37), and diabetes without complications (HR, 1.11; 95% CI, 1.00–1.23) were independent predictors of 30-day readmission (Table 2 and Figure S1). Meanwhile, a shockable arrest rhythm in index admission was not a predictor of 30-day readmission.

Causes, LOS, and costs of 30-day readmissions

Sepsis (13.7%), heart failure (10.9%), respiratory failure (6.4%), cardiac dysrhythmias (5.1%), complications of surgical procedures (4.7%), complication of device (3.7%), pneumonia (3.9%), renal failure (2.7%), and gastrointestinal hemorrhage (2.5%) were the most common causes of readmission in the cohort (Table 3). The median time from discharge to readmission was 9 (4–18) days. The median LOS for readmission was 5 (IQR 3–9) days. Among the 2090 patients readmitted within 30 days, 553 patients (10.1%) died. The median costs of index admissions with and without readmission were $40,679 (IQR 22,750–67,541) and $34,605 (IQR 19,167–60,576), respectively. The estimated total cost of readmission was $102 million (median, $ 10,498 [IQR 5797–21,364]), which accounted for 25.7% of the total episodes of care (index + readmission).

Discussion

In this analysis of a nationally representative cohort of admissions undergoing ICPR, there are several important findings. The rate of 30-day readmissions was 20.0% and was accompanied with mortality rates of 10.1%. Prolonged LOS, having insurance, the presence of comorbidities, and teaching status of the hospital were independently associated with early readmission. The main reasons for readmission were infectious, cardiogenic, and respiratory causes. The cost of readmission accounted for almost a quarter of the total amount of the care.

In the current study, the overall survival rate of index admissions who underwent ICPR was 31.0%, which is comparable with that of a previous study that reported a rate of 7%–33%.[2–5] Thirty-day readmissions are considered a quality performance metric by the Centers for Medicare and Medicaid Services to assess the quality of hospital care and to sanction hospitals with higher-than-expected readmission rates for certain conditions. While most ICPR survivors die within 30–90 days after discharge,[14] until recently, there were limited data on early readmission.[6,15] In this study, we identified that the overall rate of 30-day readmission among ICPR survivors aged $\geq$18 years was 20.0%, and the rate was 23.0% when counting the multiple readmissions. The 30-day readmission rate after ICPR was comparable to that of the most common diseases in the NRD, such as heart failure, pneumonia, and sepsis, for which the rates were 25.1%, 18.3%, and 21.4%, respectively.[16] Collectively, it should be emphasized that patient were the most vulnerable during the period immediately after discharge.

A previous study reported that age, black race, severe neurological disability, and discharge to SNF or rehabilitation facilities were associated with more inpatient resources among survivors of ICPR.[6] To our knowledge, this is the first study analyzing patient/hospital characteristics independently associated with 30-day readmissions based on NRD, which is a unique dataset that encompasses health care data from nationally representative US hospitals. Prolonged LOS was associated with increased rates of 30-day readmission in our study, which may reflect the frailty and higher burden of comorbidities. A previous study showed that the rate of 1-year survival after ICPR was significantly lower among patients with severe neurologic disability; as such, frail patients could showed increased LOS.[7] This evidence and our study suggest that continuing efforts to minimize in-hospital complications and neurological injury in the setting of CPR and post-resuscitation care are important not only in terms of improving survival but also in terms of cost and quality of care after ICPR.

Several comorbidities were identified as independent predictors of 30-day readmission after ICPR, namely, heart failure, chronic pulmonary disease, renal failure, depression, and diabetes. These findings were consistent with those of a previous study that showed an association between worse outcomes after ICPR and the Deyo–Charlson score, which is an indicator of the burden of chronic illnesses.[3] Discharge from teaching metropolitan hospitals was associated with high readmission rate in our study. Ehlenbach et al. have also reported that admission to a large metropolitan hospital was unexpectedly associated with poorer survival after ICPR.[3] This is presumed to be due to residual confounding factors, such as more severely complex cases specifically in metropolitan hospitals, which were at a higher risk of cardiac arrest. The presence of health care insurance, for example Medicare, was also associated with a higher rate of readmission. It is not surprising that the disparity in access to health care systems would lead to this finding.

Previous studies reported that patients with VT/VF after IHCA had a better prognosis than those with asystole.[10,17–19] By contrast, the 30-day readmission rate after surviving IHCA was not significantly associated with shockable arrest rhythm in our study. The risk-adjusted rates of 1-year survival among those who survived to discharge after IHCA were similar among patients with asystole, pulseless electrical activity, or pulseless VT, whereas patients with

Table 1 – Baseline patient and hospital characteristics of in-hospital cardiopulmonary resuscitation patients discharged alive after index hospitalization.

	Total	30-day readmission		p Value
		No	Yes	
N (weighted)	27278	21839	5439	
N (unweighted)	12980	10385	2595	
Female, %	43.7	43.4	45.2	0.146
Median age, years (IQR)	66 (55–76)	66 (55–76)	66 (56–76)	0.226
Age ≥70, %	40.5	39.9	42.6	0.036
Age <70, %	59.5	60.1	57.4	0.036
Median LOS, days (IQR)	11 (6–19)	10 (5–19)	13 (8–23)	<0.001
LOS ≥11, %	51.7	49.1	62.3	<0.001
LOS <11, %	48.3	50.9	37.7	<0.001
Primary expected payer				<0.001
Medicare, %	61.9	60.6	67.2	<0.001
Medicaid, %	13.6	13.3	14.7	0.102
Private, %	17.8	18.9	13.3	<0.001
Uninsured, %	3.6	3.7	3.1	0.153
Other, %	3.1	3.4	1.7	<0.001
Discharge location				<0.001
Discharged to home or self care, %	31.6	33.2	25.3	<0.001
Transfer to short-term hospital, %	6.1	6.5	4.3	0.003
Transfer to SNF, ICF, and other, %	42.6	41.7	46.6	<0.001
Home health care, %	18.6	17.8	22.0	<0.001
Against medical advice, %	1.0	0.8	1.9	<0.001
Median household income				0.276
0–25th percentile, %	32.9	32.5	34.8	0.049
26th–50th percentile, %	26.4	26.4	26.0	0.723
51th–75th percentile, %	22.8	23.0	21.8	0.299
76th–100th percentile, %	18.0	18.1	17.3	0.42
Arrest rhythm				
Shockable rhythm, %	30.6	30.6	30.7	0.895
Nonshockable rhythm, %	69.4	69.4	69.3	0.895
Elixhauser comorbidities				
Hypertension, %	62.7	62.0	65.7	0.002
Fluid and electrolyte disorders, %	60.5	60.1	62.3	0.085
Renal failure, %	30.5	28.7	37.6	<0.001
Anaemia deficiency, %	30.5	29.3	35.2	<0.001
Chronic pulmonary disease, %	26.6	25.5	30.8	<0.001
Congestive heart failure, %	25.3	23.9	31.1	<0.001
Diabetes without chronic complications, %	24.1	23.5	26.6	0.003
Obesity, %	19.0	19.2	18.5	0.472
Coagulopathy, %	16.9	16.6	18.4	0.094
Weight loss, %	16.2	15.5	18.8	0.001
Other neurological disorders, %	14.6	14.4	15.7	0.116
Peripheral vascular disease, %	12.9	12.4	14.9	0.005
Diabetes with chronic complications, %	12.3	12.2	12.8	0.471
Hypothyroidism, %	11.8	11.7	12.1	0.605
Depression, %	9.3	9.1	10.5	0.049
Pulmonary circulation disorder, %	8.0	7.6	9.3	0.011
Valvular disease, %	7.7	7.4	8.6	0.086
Alcohol abuse, %	7.5	7.7	6.5	0.029
Psychoses, %	6.1	5.9	6.8	0.145
Drug abuse, %	6.0	5.8	6.7	0.104
Paralysis, %	5.4	5.3	5.9	0.335
Liver disease, %	4.4	4.2	5.1	0.05
Rheumatoid arthritis, %	2.8	2.8	2.9	0.785
Solid tumour without metastasis, %	2.6	2.6	2.8	0.645
Metastatic cancer, %	2.1	2.2	1.8	0.226
Blood loss anaemia, %	1.9	1.9	1.9	0.995
Lymphoma, %	1.1	1.1	0.9	0.392
AIDS/HIV, %	0.4	0.3	0.6	0.145
Peptic ulcer disease, %	0.0	0.0	0.0	0.714

Table 1 ***(continued)***

	Total	30-day readmission		p Value
		No	Yes	
Median number of elixhauser comorbidities (IQR)	4 (3–6)	4 (3–6)	5 (3–6)	<0.001
≥4 elixhauser comorbidities, %	62.0	60.1	69.9	<0.001
1–3 elixhauser comorbidities, %	38.0	39.9	30.1	<0.001
Weekend admission, %	23.1	22.9	23.9	0.355
In-hospital procedure				
Mechanical ventilation, %	73.1	72.2	76.9	<0.001
Vascular catheterization, %	48.2	47.4	51.5	0.001
Blood transfusion, %	25.7	24.8	29.7	<0.001
Cardiac catheterization, %	24.1	24.6	22.1	0.018
Non-operative therapeutic cardiovascular procedures, %	18.6	18.7	18.3	0.691
Haemodialysis, %	15.2	14.1	19.6	<0.001
Pacemaker, %	11.6	11.7	11.1	0.466
Echocardiography, %	11.1	10.9	12.0	0.12
Enteral and parenteral nutrition, %	10.0	9.7	11.2	0.055
Tracheostomy, %	9.8	9.9	9.3	0.335
Bronchoscopy, %	9.4	9.3	9.9	0.422
Thoracentesis, %	8.7	8.7	8.6	0.838
Gastrostomy, %	8.0	7.8	8.6	0.225
Other operative heart procedure, %	7.8	7.8	8.0	0.686
Extracorporeal circulation auxiliary to open heart procedures, %	6.8	6.7	7.2	0.425
Upper gastrointestinal endoscopy, %	6.4	6.3	6.6	0.643
CABG, %	4.4	4.3	4.6	0.582
Bed size				0.293
Small, %	12.3	12.4	11.8	0.558
Medium, %	25.4	25.6	24.6	0.387
Large, %	62.3	62.0	63.5	0.279
Location				0.028
Metropolitan ≥1 million, %	58.0	57.5	60.0	0.088
Metropolitan <1 million, %	36.1	36.2	35.6	0.711
Micropolitan, %	5.0	5.3	3.7	0.003
Rural, %	1.0	1.1	0.7	0.093
Teaching status				0.549
Teaching metropolitan, %	66.6	65.7	70.1	<0.001
Non-teaching metropolitan, %	27.5	27.9	25.6	0.049
Non-metropolitan, %	6.0	6.4	4.3	<0.001

LOS, length of stay; IQR, interquartile range; SNF, skilled nursing facility; ICF, intermediate care facility; AIDS, acquired immunodeficiency syndrome; HIV, human immunodeficiency virus; CABG, coronary artery bypass grafting.

VF had a slightly higher rate of survival (HR, 1.09; 95% CI, 1.04–1.15).[15] Collectively, we speculated that the impact of the initial rhythm of IHCA affects early outcomes, but the severity of comorbidities might have a more important impact in the subsequent periods, specifically after survived discharge. This notion would be supported by the fact that readmissions for a primary diagnosis of cardiac arrest were rarely observed; they were <1% in both a previous and the current study.[6]

Readmissions after ICPR were due to various causes, including sepsis (13.7%), congestive heart failure (10.9%), and respiratory failure (6.4%). Interestingly, it was consistent with the 3 most common diagnosis categories for the index event for 30-day readmissions within the NRD,[16] which reflects the heterogeneous causes of IHCA. Chan et al. reported similar results for principal causes of 30-day readmission after ICPR, namely, heart failure (16.7%), gastrointestinal bleeding (7.9%), medical/surgical complications (6.3%), sepsis (5.9%), renal diseases (5.9%), pneumonia (4.4%), and acute respiratory failure (4.1%).[6] Aside from resource consumption, our study showed for the first time that readmissions after ICPR required a significant economic input, with an annual total cost of $102 million (median: $10,498 [IQR 5797–21,364]), which accounted for 25.7% of the total episodes of care. Therefore, improved prevention and early interventions in the course of management are important in improving outcomes over the short-term for these patients.

Limitations

Our study has several limitations. First, our analysis was based on administrative data, which lack clinical and laboratory variables. Specifically, NRD lacks accurate information on pre/post-resuscitation ECG findings, location of cardiac arrest, time to defibrillation, and important neurological outcome determinants such as cerebral performance category. Second, patients who were readmitted across different states were not included in this study, however, it is presumed that such patients account for a small proportion of all the patients.

Table 2 – Independent predictors of 30-day readmission after in-hospital cardiopulmonary resuscitation via univariate and multivariate Cox proportional hazards regression analysis.

Predictors	Univariate			Multivariate		
	HR	95% CI	p value	HR	95% CI	p value
LOS ≥11 days	1.61	1.48–1.76	<0.00001	1.43	1.30–1.58	<0.00001
Chronic pulmonary disease	1.26	1.13–1.40	0.00002	1.21	1.09–1.34	0.00051
Congestive heart failure	1.38	1.26–1.51	<0.00001	1.19	1.07–1.32	0.00127
Renal failure	1.42	1.30–1.56	<0.00001	1.19	1.06–1.34	0.00403
Teaching metropolitan	1.19	1.07–1.33	0.00117	1.16	1.04–1.29	0.00862
Medicare	1.29	1.17–1.41	<0.00001	1.15	1.04–1.27	0.00894
Depression	1.16	1.00–1.34	0.04605	1.18	1.01–1.37	0.03551
Diabetes without chronic complications	1.16	1.05–1.28	0.00333	1.11	1.00–1.23	0.04702
Liver disease	1.22	1.01–1.48	0.04355			
Alcohol abuse	0.85	0.73–0.99	0.03220			
Haemodialysis	1.42	1.28–1.57	<0.00001			
Discharged to home or self care	0.71	0.64–0.79	<0.00001			
Micropolitan	0.71	0.56–0.90	0.00529			
Anaemia deficiency	1.26	1.14–1.39	<0.00001			
Vascular catheterization	1.16	1.06–1.27	0.00115			
Blood transfusion	1.25	1.13–1.38	0.00002			
Peripheral vascular disease	1.20	1.06–1.36	0.00470			
Weight loss	1.22	1.08–1.38	0.00142			
Pulmonary circulation disorder	1.22	1.05–1.42	0.00889			
Hypertension	1.15	1.05–1.25	0.00237			
Age ≥70	1.1	1–1.21	0.04144			
Mechanical ventilation	1.25	1.13–1.39	0.00002			
Cardiac catheterization	0.884	0.795–0.984	0.02347			

LOS, length of stay.

Table 3 – Causes of 30-day readmission after in-hospital cardiopulmonary resuscitation.

Causes	Proportion (%)	Total number (Weighted)
Sepsis	13.7	746
Congestive heart failure	10.9	593
Respiratory failure	6.4	349
Cardiac dysrhythmias	5.1	277
Complications of surgical procedures or medical care	4.7	256
Complication of device, implant, or graft	3.7	200
Pneumonia	3.9	215
Acute and unspecified renal failure	2.7	149
Gastrointestinal haemorrhage	2.5	138
Nonspecific chest pain	3	164
Diabetes mellitus with complications	2.4	133
Fluid and electrolyte disorders	2.3	123
Hypertension with complications and secondary hypertension	2.1	112
Acute myocardial infarction	2.1	112
Urinary tract infections	1.5	81
Chronic obstructive pulmonary disease and bronchiectasis	1.4	76
Pulmonary heart disease	1.3	71
Aspiration pneumonitis; food/vomitus	1.2	67
Coronary atherosclerosis and other heart disease	1.4	75
Deficiency and other anaemia	1	53
Acute cerebrovascular disease	1	55
Other nervous system disorders	0.8	46
Others	24.9	1348
Total	100	5439

Third, we identified readmission after ICPR using ICD-9-CM procedure codes causing incorrect classification and underestimation. However, similar methods have been used in previous studies on ICPR.[2,9,10] Finally, since mortality and cost data on ICPR survivors who died outside the hospital or emergency room were not available, we could not analyze based on these factors. Despite these limitations, we believe that the NRD provides valuable and powerful information in the context of the quality of care and cost immediately after ICPR. Considering the heterogeneous causes and impactful nature of IHCA, a comprehensive evaluation of the intervention should be conducted in future, targeting various predictors using a clinically multidisciplinary approach.

Conclusions

Thirty-day readmissions after ICPR were frequent. Certain patient/hospital characteristics were independently associated with readmissions, namely, LOS ≥11 days, presence of Medicare insurance, presence of several comorbidities, and discharge home or to health care facilities. Sepsis, heart failure, and respiratory failure were the most common overall cause of readmission. Recognition of these predictors will allow for high-risk patients to be identified and for interventions to be devised to reduce healthcare costs and the frequency of readmissions.

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Conflicts of interest

The authors report no relationships that could be construed as a conflict of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2018.12.001.

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