International Journal of Gerontology 20 (2026) 46–54
https://doi.org/10.6890/IJGE.202601_20(1).0008

International Journal of Gerontology

journal homepage: http://www.sgecm.org.tw/ijge/

Original Article

Factors Associated with Survival among Older Patients with In-Hospital Cardiac Arrest: A Population-Based Study

Chi-Chang Huang [a,b], Ching Ju Chiu [c], Fang-Wen Hu [d], Deng-Chi Yang [a,b], Yu-Tai Lo [a], Chia-Ming Chang [a,b,c,e] *

[a] *Department of Geriatrics and Gerontology, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan,* [b] *Department of Internal Medicine, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan,* [c] *Institute of Gerontology, College of Medicine, National Cheng Kung University, Tainan, Taiwan,* [d] *School of Nursing, College of Nursing, Kaohsiung Medical University, Kaohsiung, Taiwan,* [e] *Department of Medicine, College of Medicine, National Cheng Kung University, Tainan, Taiwan*

ARTICLE INFO

Accepted 16 June 2025

Keywords:
cardiac arrest,
cardiopulmonary resuscitation,
elderly,
survival

SUMMARY

Background: This study determined the factors that affect survival to discharge and 1-year survival among older adults with in-hospital cardiac arrest who underwent cardiopulmonary resuscitation (CPR).
Methods: A retrospective longitudinal cohort study based on data from Taiwan's National Health Insurance Research Database from January 1, 2000, to December 31, 2012. A population-based study including 6034 eligible participants aged ≥ 65 years who underwent a first CPR event. Demographic factors, comorbidities, main admission diagnoses, CPR process, and tube dependency were assessed. Logistic regression analysis was used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the probability of survival to discharge and the association between risk factors and 1-year survival.
Results: In the survival-to-discharge model, either univariate or multivariate analysis, patients with age ≥ 85 years, with a main diagnosis of infection or malignancy at admission, with nonventricular fatal arrhythmia or longer duration of cardiac massage, and requiring a nasogastric tube were less likely to be successfully resuscitated. The following factors decreased 1-year survival among surviving older adults with noncritical discharge: older age, male sex, high Charlson–Deyo Comorbidity Index (CCI) scores, and long-term tube dependency after CPR, with the need for three tubes being the strongest risk factor (OR: 6.818, 95% CI: 4.068–11.427, $p < 0.001$).
Conclusions and Implications: CPR process was the most important factor of survival to discharge among older adults with in-hospital cardiac arrest, and long-term multiple-tube dependency, which implies functional deficits, was the strongest factor affecting 1-year survival.

1. Introduction

Cardiopulmonary resuscitation (CPR) is the standard procedure for treating cardiac arrest. CPR for in-hospital cardiac arrest has become more effective in restoring circulation and prolonging life in some groups, such as younger adults, children, and cardiac patients.[1,2] However, several large epidemiologic surveys have revealed that the real rate of survival to hospital discharge after in-hospital cardiac arrest among older adults (aged ≥ 65 years) was as low as < 20% and that the survival trend of patients with severe neurological disability has not significantly improved despite recent medical advancements.[2–4]

In addition to the survival-to-discharge rate, the long-term survival status after in-hospital cardiac arrest also affects the willingness to accept CPR. Long-term survival outcomes remain unsatisfactory among older adults after in-hospital CPR.[4–6] The survival outcome is affected by multiple factors. A 2021 study revealed extremely poor prognosis after in-hospital cardiac arrest among patients with COVID-19, suggesting that admission diagnosis may play a major role in post-CPR survival outcomes.[7] A systematic review of studies from 1985 to 2018 observed that the 1-year survival rate after in-hospital cardiac arrest was approximately 13.4% but with significant between-study heterogeneity in outcomes,[8] thereby necessitating further studies to more comprehensively assess specific prognostic factors for long-term post-CPR survival.

In clinical practice, if CPR only prolongs death, disability, or the need for intensive medical care, most families will refuse CPR.[9,10] However, few large-scale epidemiological studies have attempted to present the whole picture of survival status by comparing the weight of the various factors that influence short- to long-term survival, such as the CPR process, comorbidity factors, ward factors, main admission diagnosis, and functional decline. Thus, in this retrospective cohort study, we analyzed national longitudinal data to investigate the epidemiology and associated factors of survival to discharge and 1-year survival after CPR among hospitalized older patients.

2. Materials and methods

2.1. Data source and design

Taiwan's National Health Insurance Research Database (NHIRD), which has collected the data from the National Health Insurance

* Corresponding author. Department of Geriatrics and Gerontology, National Cheng Kung University Hospital, Tainan, Taiwan.
E-mail address: 10108040@gs.ncku.edu.tw (C.-M. Chang)

program since 1995, is a long-term nationwide electronic database and has been validated in past studies.[11] Its data are drawn from 97% of medical providers in Taiwan, and it covers > 99% of the 23 million people in Taiwan. The data that support the findings of this study are available from Health and Welfare Data Science Center but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. We designed a retrospective cohort study to investigate the epidemiology and survival factors of hospitalized older adults who underwent CPR between January 1, 2000, and December 31, 2012.

2.2. Measures and variables

We collected data on patient demographics, hospital characteristics, unit in which CPR was undergone, baseline comorbidities, Charlson-Deyo Comorbidity Index (CCI) of score,[12,13] main admission diagnosis, CPR process, tube dependency, diagnosis and procedure codes of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM),[4] survival status, and date of death. Because of database limitations, all patients older than 85 years were classified as ≥ 85 years old. We reclassified medical centers and university-affiliated hospitals as tertiary-level hospitals. Tube dependency, such as the need for a Foley catheter, nasogastric tube feeding, or tracheostomy, was used to represent functional deficits in older patients. The CPR records were retrieved using diagnostic codes for cardiac arrest (427.5), ventricular tachycardia (VT, 427.1), ventricular fibrillation (VF, 427.41), and ventricular flutter (VFL, 427.42) or ICD-9-CM procedure codes 93.93 (nonmechanical methods of resuscitation), 99.60 (cardiopulmonary resuscitation, not otherwise specified), 99.63 (closed cardiac massage), or 96.04 (insertion of endotracheal tube).

Comorbidities,[14] including hypertension, diabetes mellitus, heart disease, hyperlipidemia, chronic obstructive lung disease, heart failure, acute coronary artery disease, stroke, Parkinson's disease, dementia, cirrhosis, peptic ulcer disease, malignancy, osteoporosis, and renal disease, were recorded when the selected ICD-9-CM codes were present in the claims data of enrollees for an average of more than twice per year during the observation period. The CCI scores were divided into three groups as in other studies[15,16] for representing the severity of comorbidity. In this study, we linked the "Cause Of Death Data (H_OST_DEATH)"[17] to our study group, and nonsurvival to discharge was considered when the patient's discharge destination was coded as death.

2.3. Study papulation and outcome

From January 1, 2000, to December 31, 2012, 8593 CPR events were recorded. In order to prevent left-censoring, we included only patients who experienced their first CPR event between January 1, 2002, and December 31, 2012 and excluded 47 cases who have CPR between January 1, 2000, and December 31, 2001. We also excluded patients < 65 years of age (n = 2512). Eventually, the data of 6034 older adults were included for analysis.

The primary outcomes of this study were survival to discharge and 1-year survival condition. To measure the impact factors of long-term survival, we excluded cases that died within 1 week of critical discharge, who we categorized as the nonsurvival to discharge group and analyzed using sensitivity analysis (Supplement Table 1 and Table 2).

2.4. Statistical analysis

Data extraction and statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA). Categorical variables are expressed as numbers and percentages, and continuous variables are expressed as means ± standard deviations. Comparisons between the survivor and nonsurvivor groups were conducted using chi-square tests for categorical variables and t tests for continuous variables. Variables with two-tailed $p < 0.05$ on univariate tests were included in a multivariate logistic regression model. Multivariate logistic regression was used to analyze the survival-to-discharge model and to determine the contributors to the dependent variable. The logistic regression model, with censoring on December 31, 2012, was used to examine the association between possible risk factors and 1-year mortality. We also checked variance inflation factors to investigate and rule out multicollinearity among the independent variables. To determine the mortality rate among patients with long-term tube dependency (determined as the numbers of medical tubes required during the 1-year follow-up period), the Kaplan–Meier survival analysis model adjusted for age and sex was used to provide the accumulated probability of survival. All tests were considered significant at $p < 0.05$.

2.5. Ethical approval

This study was reviewed and approved by the Human Experiment and Ethics Committee of National Cheng Kung University Hospital (approval number: NCKUH, B-EX-106-005), Taiwan.

3. Results

We included 6034 patients aged ≥ 65 years (median: approximately 79 years) in our analysis. More than half (61.00%) of the patients were men, and 34.67% had functional impairment with at least one long-term placement of a medical tube (Foley catheter: 27.93%, nasogastric tube: 22.11%, and/or tracheostomy tube: 12.86%) to maintain life before CPR events (Table 1). Among these patients with functional impairment, one-fourth had severe tube dependency, requiring three tubes.

The most common main admission diagnoses were respiratory disease (38.76%), heart disease (20.80%), and infection (11.55%). The most common comorbidities were hypertension (63.67%), heart disease (42.82%), chronic obstructive pulmonary disease (38.60%), diabetes mellitus (37.40%), and stroke (36.73%). Most CPR events occurred in the internal medicine ward (84.05%). Only fewer than 5% of cases had pulseless VT or VF during CPR. The duration of most CPR events (96.91%) was < 10 min.

The survival-to-discharge rate after CPR was approximately 11.09%. Table 1 presents the univariate analysis for characteristics between survivors and nonsurvivors of discharge after in-hospital CPR. Risks of mortality after in-hospital CPR were relatively high with older age, male sex, in-hospital CPR events occurring at nontertiary hospitals, long-term tube dependency, prolonged CPR duration, fatal nonventricular arrhythmia, higher comorbidity scores, and main admission diagnosis of infection or malignancy.

Multiple logistic regression analysis (Table 2) revealed that older age, male sex, longer duration of cardiac massage, main admission diagnosis of malignancy or infection, fatal nonventricular arrhythmia, and nasogastric feeding tube were independently associated with lower survival-to-discharge rate after in-hospital CPR. Among these, cardiac massage duration > 10 min (odds ratio [OR]: 3.764, 95% CI: 2.179–6.503, $p = 0.005$) and main admission diagnosis of malignancy (OR: 2.313, $p = 0.003$) were the most influential factors. If the cause of cardiac arrest is VT or VF, the prognosis of survival to discharge is relatively good.

Table 1
Baseline clinical characteristics and univariate analysis between older adults who survived to discharge and non-survivors.

Variables	Total N = 6034 (%)	Survival status: Yes, N = 669(%)	Survival status: No, N = 5365 (%)	p-value
Age, years				
Median	79	78	80	
By group				0.007
65–69	677 (11.22)	90 (13.45)	587 (10.94)	
70–74	1008 (16.71)	128 (19.13)	880 (16.40)	
75–79	1351 (22.39)	162 (24.21)	1189 (22.16)	
80–84	1495 (24.78)	151 (22.57)	1344 (25.05)	
≥ 85	1503 (24.91)	138 (20.63)	1365 (25.44)	
Sex				0.043
Male	3681 (61.00)	384 (57.40)	3297 (61.45)	
Residence				0.491
Municipalities	3316 (54.96)	376 (56.20)	2940 (54.80)	
Non-municipalities	2718 (45.04)	293 (43.80)	2425 (45.20)	
Hospital characteristics				< 0.001
Tertiary level hospitals	428 (7.09)	70 (10.46)	358 (6.67)	
Others	5606 (92.91)	599 (89.54)	5007 (93.33)	
CPR received unit				
Internal medicine	5034 (83.43)	561 (83.86)	4473 (83.64)	0.752
Others	1000 (16.58)	108 (16.14)	892 (11.63)	
Chronic diseases				
Hypertension	3842 (63.67)	446 (66.67)	3396 (63.30)	0.087
Diabetes mellitus	2257 (37.40)	272 (40.66)	1985 (37.00)	0.065
Hyperlipidemia	658 (10.90)	90 (13.45)	568 (10.59)	0.025
COPD	2329 (38.60)	231 (34.53)	2098 (39.11)	0.022
Heart failure	2584 (42.82)	305 (45.59)	2279 (42.48)	0.125
CAD	1949 (32.30)	246 (36.77)	1703 (31.74)	0.009
Stroke	2216 (36.73)	246 (36.77)	1970 (36.72)	0.979
Parkinson disease	468 (7.76)	54 (8.07)	414 (7.72)	0.746
Dementia	1238 (20.52)	125 (18.68)	1113 (20.75)	0.213
Cirrhosis	488 (8.09)	50 (7.47)	438 (8.16)	0.537
Peptic ulcer disease	1575 (26.10)	158 (23.62)	1417 (26.41)	0.121
Malignancy	835 (13.84)	74 (11.06)	761 (14.18)	0.027
Chronic kidney disease	1360 (22.54)	156 (23.32)	1204 (22.44)	0.608
Osteoporosis	485 (8.04)	61 (9.12)	424 (7.90)	0.276
Charlson comorbidity index score (mean ± SD)	3.03 ± 2.36	2.83 ± 2.05	3.06 ± 2.40	< 0.001
By group				0.394
0	597 (9.89)	70 (10.46)	527 (9.82)	
1–2	2311 (38.30)	259 (38.71)	2052 (38.25)	
3–4	1934 (32.05)	224 (33.48)	1710 (31.87)	
≥ 5	1192 (19.75)	116 (17.34)	1076 (20.06)	
Admission main diagnosis				
Respiratory	2339 (38.76)	267 (39.91)	2072 (38.62)	0.518
Cardiovascular	1255 (20.80)	162 (24.22)	1093 (20.37)	0.021
Infection	697 (11.55)	62 (9.27)	635 (11.84)	0.050
Ill-defined	357 (5.92)	34 (5.08)	323 (6.02)	0.332
Neoplasm/hematology	322 (5.34)	20 (2.99)	302 (5.63)	0.004
Gastrointestinal	316 (5.24)	27 (4.04)	289 (5.39)	0.139
Genitourinary	213 (3.53)	18 (2.69)	195 (3.63)	0.212
Initial arrest rhythm				
VFL/VF/VT	249 (4.13)	56 (8.37)	193 (3.60)	< 0.001
Duration of cardiac massage cycle				< 0.001
1(< 10min)	655 (10.86)	162 (24.22)	493 (9.19)	
2 (10–20 mins)	5193 (86.06)	490 (73.24)	4703 (87.66)	
≥ 3 (> 20 mins)	186 (3.08)	17 (2.54)	169 (3.15)	
Intubation	4113 (68.18)	453 (67.71)	3660 (68.22)	0.790
Defibrillation	1401 (23.22)	148 (22.12)	1253 (23.36)	0.477
Pre-CPR medical tube				
Urinary catheter	1685 (27.93)	177 (26.46)	1508 (28.11)	0.369
NG/gastrostomy/jejunostomy	1334 (22.11)	126 (18.83)	1208 (22.52)	0.031
Tracheostomy	770 (12.86)	92 (13.75)	684 (12.75)	0.465
Numbers of pre-CPR medical tubes				0.005
0	3942 (65.33)	457 (68.31)	3485 (64.96)	
1	915 (15.16)	97 (14.50)	818 (15.25)	
2	651 (10.79)	47 (7.03)	604 (11.26)	
3	526 (8.72)	68 (10.16)	458 (8.58)	

CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CPR: cardiopulmonary resuscitation, NG: nasogastric, VF: ventricular fibrillation, VFL: ventricular flutter, VT: ventricular tachycardia.

Table 2
Multivariate analysis of factors related to nonsurvival to discharge.

Variables	Model A OR (95% CI)	*p* values	Model B OR (95% CI)	*p* values	Model C OR (95% CI)	*p* values
Age (ref :65–69)		0.025		0.027		0.024
70–74	1.026 (0.792–1.439)	0.243	1.067 (0.792–1.438)	0.246	1.070 (0.794–1.083)	0.240
75–79	1.093 (0.820–1.457)	0.319	1.095 (0.821–1.459)	0.336	1.110 (0.825–1.467)	0.344
80–84	1.322 (0.985–1.773)	0.172	1.314 (0.979–1.762)	0.191	1.320 (0.984–1.769)	0.189
≥ 85	1.500 (1.110–2.028)	0.005	1.499 (1.110–2.026)	0.005	1.510 (1.117–2.040)	0.005
Sex (ref: female)						
Male	1.145 (0.962–1.362)	0.128	1.144 (0.961–1.361)	0.131	1.143 (0.961–1.360)	0.131
Hospital characteristics (ref: medical center)						
Non-tertiary level hospitals	1.290 (0.970–1.714)	0.080	1.287 (0.968–1.712)	0.083	1.281 (0.964–1.704)	0.088
Comorbidity (ref: non)						
Hypertension	0.934 (0.766–1.134)	0.490	0.934 (0.769–1.134)	0.491	0.934 (0.768–1.135)	0.491
Diabetes mellitus	0.925 (0.772–1.109)	0.400	0.929 (0.776–1.112)	0.421	0.926 (0.774–1.109)	0.406
Hyperlipidemia	0.853 (0.662–1.099)	0.219	0.857 (0.665–1.104)	0.231	0.853 (0.662–1.098)	0.217
COPD	1.058 (0.872–1.283)	0.569	1.090 (0.898–1.323)	0.382	1.074 (0.885–1.302)	0.470
Heart failure	0.939 (0.775–1.138)	0.524	0.961 (0.793–1.164)	0.682	0.945 (0.780–1.145)	0.561
CAD	0.852 (0.707~1.026)	0.092	0.860 (0.714–1.035)	0.110	0.839 (0.696–1.010)	0.064
Stroke	0.906 (0.750–1.095)	0.307	0.936 (0.774–1.133)	0.498	0.922 (0.764–1.114)	0.401
Parkinson disease	0.910 (0.668–1.240)	0.550	0.910 (0.668–1.240)	0.549	0.906 (0.665–1.235)	0.533
Dementia	1.050 (0.838–1.317)	0.670	1.081 (0.862–1.357)	0.500	1.051 (0.838–1.317)	0.668
Liver cirrhosis	1.017 (0.735–1.407)	0.919	1.055 (0.764–1.459)	0.744	1.024 (0.740–1.416)	0.887
Peptic ulcer disease	1.078 (0.877–1.326)	0.474	1.115(0.906–1.371)	0.304	1.082 (0.880–1.330)	0.454
Malignancy	1.095 (0.787–1.524)	0.589	1.191 (0.870–1.630)	0.276	1.076 (0.773–1.498)	0.663
Renal disease	1.031 (0.823–1.290)	0.793	1.091 (0.868–1.371)	0.454	1.025 (0.819–1.282)	0.832
Osteoporosis	0.885 (0.659–1.190)	0.419	0.895 (0.667–1.202)	0.436	0.889 (0.662–1.195)	0.436
Charlson comorbidity index score						
By score	1.026 (0.970–1.085)	0.376			1.024 (0.968–1.083)	0.402
By group* (ref: 0)						
1–2			1.018 (0.749–1.383)	0.654		
3–4			0.914 (0.640–1.306)	0.333		
≥ 5			1.009 (0.653–1.559)	0.829		
Initial arrest rhythm (ref: non)						
VF/VFL/VT	0.441 (0.313–0.622)	< 0.001	0.442 (0.314–0.623)	< 0.001	0.432 (0.306–0.608)	< 0.001
Admission main diagnosis (ref: non)						
Infection	1.584 (1.101–2.279)	0.013	1.591 (1.107–2.287)	0.012	1.567 (1.089–2.254)	0.015
Neoplasm	2.293 (1.318–3.991)	0.003	2.385 (1.374–4.138)	0.002	2.342 (1.345–4.079)	0.003
Cardiovascular disease	1.301 (0.961–1.763)	0.089	1.311 (0.968–1.776)	0.080	1.308 (0.966–1.772)	0.083
Respiratory disease	1.162 (0.874–1.544)	0.301	1.155 (0.870–1.535)	0.320	1.150 (0.866–1.529)	0.334
Gastrointestinal disease	1.746 (1.088–2.800)	0.021	1.763 (1.099–2.828)	0.019	1.737 (1.083–2.787)	0.022
Genitourinary disease	1.680 (0.968–2.915)	0.065	1.684 (0.971–2.921)	0.064	1.693 (0.945–2.842)	0.079
Ill define	1.524 (0.984–2.361)	0.059	1.538 (0.993–2.381)	0.054	1.524 (0.984–2.360)	0.059
Duration of cardiac massage cycle (ref: 1)						
2 (10–20 mins)	3.235 (2.611–4.007)	< 0.001	3.173 (2.557–3.939)	< 0.001	3.162 (2.547–3.924)	< 0.001
≥ 3 (> 20 mins)	3.922 (2.270–6.766)	0.003	3.764 (2.179–6.503)	0.005	3.748 (2.169–6.474)	0.005
Intubation	1.104 (0.895–1.361)	0.357	1.098 (0.890–1.354)	0.382	1.098 (0.890–1.355)	0.382
Defibrillation	0.752 (0.641–0.883)	< 0.001	0.804 (0.664–0.973)	0.025	0.819 (0.677–0.990)	0.039
Pre-CPR medical tube (ref: non)						
Urinary catheter	1.002 (0.793–1.265)	0.987	1.010 (0.801–1.273)	0.931		
NG/gastrostomy/jejunostomy	1.334 (1.007–1.766)	0.044	1.351 (1.023–1.785)	0.034		
Tracheostomy	0.718 (0.526–0.981)	0.037	0.733 (0.536–1.002)	0.052		
Numbers of pre-CPR medical tube (ref: 0)						
1					1.083 (0.843–1.391)	0.993
2					1.545 (1.008–2.155)	0.044
3					0.825 (0.609–1.117)	0.170

CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CPR: cardiopulmonary resuscitation, NG: nasogastric, VF: ventricular fibrillation, VFL: ventricular flutter, VT: ventricular tachycardia.
Model A. The variables adjusted in the regression models were age, sex, hospital characteristics, comorbidity, by scores of Charlson comorbidity index score, Initial arrest rhythm, admission main diagnosis, duration of cardiac massage cycle, intubation, pre-CPR medical tube.
Model B. The variables adjusted in the regression models were age, sex, hospital characteristics, comorbidity, by groups of Charlson comorbidity index score, Initial arrest rhythm, admission main diagnosis, duration of cardiac massage cycle, intubation, pre-CPR medical tube.
Model C. The variables adjusted in the regression models were age, sex, hospital characteristics, comorbidity, by scores of Charlson comorbidity index score, Initial arrest rhythm, admission main diagnosis, duration of cardiac massage cycle, intubation, numbers of pre-CPR medical tube.

Among those who survived to discharge, 43.46% survived for more than 1 year. Table 3 presents their characteristics. The median age was higher in the 1-year nonsurvivor group (80 vs. 76 years). The overall mean score of Charlson–Deyo Comorbidity Index was 2.73 ± 2.01, with 2.51 ± 1.87 in the survivor group and 2.99 ± 2.09 in the nonsurvivor group. In the univariate analysis of 1-year survival model,

Table 3
Univariate analysis between 1-year survivors and nonsurvivors among survived older adults with noncritical discharge.

Variables	Total N = 474 (%)	Survival status		p-value
		Yes, N = 206 (%)	No, N = 268 (%)	
Age, years				
Median	78	76	80	
By group				< 0.001
65–69	69 (14.56)	40 (19.42)	29 (10.82)	
70–74	89 (18.78)	45 (21.84)	44 (16.41)	
75–79	110 (23.21)	53 (25.73)	57 (21.27)	
80–84	113 (23.84)	33 (16.02)	80 (29.85)	
≥ 85	93 (19.62)	35 (16.99)	58 (21.64)	
Sex				
Male	265 (55.90)	107 (51.94)	158 (58.96)	0.127
Residence				
Municipalities	281 (59.28)	122 (59.22)	159 (59.33)	0.981
Hospital characteristics				
Tertiary level hospitals	57 (12.03)	28 (13.59)	29 (10.82)	0.358
CPR received unit				
Internal medicine	401 (84.60)	170 (82.52)	231 (86.19)	0.273
Chronic diseases				
Hypertension	323 (68.14)	142 (68.93)	181 (67.54)	0.747
Diabetes mellitus	201 (42.40)	86 (41.75)	115 (42.91)	0.800
Hyperlipidemia	69 (14.56)	34 (16.50)	35 (13.06)	0.292
COPD*[a]	164 (34.60)	69 (33.50)	95 (35.45)	0.658
Heart failure	224 (47.26)	101 (49.03)	123 (45.90)	0.498
CAD*[b]	175 (36.92)	77 (37.38)	98 (36.57)	0.856
Stroke	175 (36.92)	70 (33.98)	105 (39.18)	0.245
Parkinson disease	35 (7.38)	18 (8.74)	17 (6.34)	0.323
Dementia	93 (19.62)	35 (16.99)	58 (21.64)	0.206
Cirrhosis	31 (6.54)	20 (9.71)	11 (4.10)	0.014
Peptic ulcer disease	114 (24.05)	45 (21.84)	69 (25.75)	0.325
Malignancy	51 (13.84)	18 (8.74)	33 (12.31)	0.213
Chronic kidney disease	106 (22.36)	39 (18.93)	67 (25.00)	0.116
Osteoporosis	45 (9.49)	20 (9.71)	25 (9.33)	0.889
Charlson comorbidity index score (mean ± SD)	2.728 ± 2.01	2.51 ± 1.87	2.99 ± 2.09	< 0.001
By group				0.131
0	46 (9.70)	24 (11.65)	22 (8.21)	
1–2	190 (40.08)	91 (44.17)	99 (36.94)	
3–4	160 (33.75)	62 (30.10)	98 (36.57)	
≥ 5	78 (16.46)	29 (14.07)	49 (18.28)	
Admission main diagnosis				
Respiratory	198 (41.77)	81 (39.32)	117 (43.65)	0.343
Cardiovascular	119 (25.11)	53 (25.72)	66 (24.62)	0.784
Infection	34 (7.17)	12 (5.82)	22 (8.21)	0.319
Ill-defined	19 (4.01)	7 (3.40)	12 (4.48)	0.332
Gastrointestinal	22 (4.64)	12 (5.82)	10 (3.73)	0.282
Endocrine	13 (2.74)	5 (2.42)	8 (2.98)	0.712
Genitourinary	11 (2.32)	6 (2.91)	5 (1.86)	0.453
Neoplasm/hematology	10 (2.11)	3 (1.46)	7 (2.61)	0.386
Initial arrest rhythm				
Vf/VF/VT[c]	48 (10.13)	22 (10.68)	26 (9.70)	0.883
Cardiac massage cycle				0.535
1 (< 10 min)	130 (27.43)	55 (26.70)	75 (27.99)	
2 (10–20 mins)	336 (70.89)	146 (70.87)	190 (70.90)	
≥ 3 (> 20 mins)	8 (1.69)	5 (2.43)	3 (1.12)	
Intubation	321 (67.77)	136 (66.02)	185 (69.03)	0.487
Defibrillation	107 (22.57)	41 (19.90)	66 (24.62)	0.223
Post-CPR medical tube				
Urinary catheter	267 (56.33)	85 (41.26)	182 (67.91)	< 0.001
NG/gastrostomy/jejunostomy	314 (66.24)	102 (49.51)	212 (79.10)	< 0.001
Tracheostomy	274 (57.81)	76 (36.89)	198 (73.88)	< 0.001
Numbers of post-CPR medical tubes				< 0.001
0	131 (27.64)	93 (45.15)	38 (14.18)	
1	43 (9.1)	21 (10.19)	22 (8.20)	
2	88 (18.56)	34 (16.50)	54 (20.15)	
3	212 (44.73)	58 (28.16)	154 (57.46)	

CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CPR: cardiopulmonary resuscitation, NG: nasogastric, VF: ventricular fibrillation, VFL: ventricular flutter, VT: ventricular tachycardia.

the long-term survival probability decreased if patients were older, had higher Charlson–Deyo Comorbidity Index scores, or had long-term tube dependency (especially three tubes) after CPR (Table 3). CPR procedure-related variables, which had important impacts on survival to discharge, had little effect on 1-year survival.

Because only 474 patients survived beyond 1 year (Table 4), we only included age, sex, and variables with $p < 0.1$ in the univariate analysis and chronic diseases in the long-term survival model for comparison. In addition to age and sex, multivariate analysis indicated that the need for long-term tracheostomy tubing after CPR or more medical tubes (three types) were the strongest predictors of 1-year nonsurvival. Multivariate analysis of continuous CCI scores also revealed a significant association with long-term survival.

Kaplan–Meier analysis (Figure 1A) of the 1-year survival of post-CPR cases revealed survival probabilities of 70.99% in patients without tube dependency and 48.37%, 38.63%, and 27.36% in those requiring one, two, and three medical tubes ($p < 0.001$). Tests of Kaplan–Meier survival curves were performed using a weighted model, after adjustment for age and sex. In the comorbidity model, only patients with lower CCI scores had better survival probability but the overall model was not statistically significant ($p = 0.371$; Figure 1B).

4. Discussion

Although CPR is a standard emergency life-saving procedure for cardiac arrest, most hospitalized older adults requiring CPR are unlikely to survive to discharge. Several large epidemiological studies have concluded that the survival-to-discharge rateis usually < 20% and decreases with age.[2,3] Adams and Snedden indicated that in general, the effectiveness of CPR in older adults is grossly overestimated: > 80% of older patients believe that their chance of surviving to discharge after CPR is ≥ 50%.[18] The actual survival rates to discharge after CPR among older adults decrease with many factors and are much lower than assumed by the general public.[2,3,4,7]

Higher chances of survival to discharge have been noted in certain situations, such as short CPR duration and arrhythmias (VT, VF, or VFL), but groups with these circumstances often constitute only a small minority.[19–21] Our 13-year nationwide population-based cohort study also indicated that short CPR duration, VT, VF, VFL, and younger age are associated with better prognoses, but these groups only accounted for < 25% of all events. Notably, the survival-to-discharge rate among older groups with VT, VF, or VFL arrhythmia was as high as 22.0% but only 10.5% among those with asystole and pulseless electrical activity. This phenomenon reminds us to be careful to distinguish whether an arrhythmia requires defibrillation during CPR for older patients.

Other significant factors of worse prognosis were the main admission diagnoses of infection or malignancy and long-term placement of a nasogastric tube before CPR, consistent with previous studies.[22,23] The effect of infection could also be seen in Chan's recent study designed to assess cardiac arrest survival during the COVID-19 pandemic, with the study showing that rates of survival to discharge after in-hospital cardiac arrest decreased, even among patients without COVID-19.[24] The survival-to-discharge rate of patients hospitalized with a main diagnosis of malignancy decreased to 6.2%. In older adults hospitalized due to malignancy-associated complications, the benefits of aggressive CPR should be seriously considered. The indications for nasogastric feeding are usually malnutrition caused by dysphagia or anorexia in intercurrent illness or chronic disease. Although nasogastric tube feeding in older adults has different prognoses in different situations,[25] our data highlight poor prognosis after in-hospital CPR in these patients.

Few studies have explored the actual short- and long-term survival of older patients who survived after discharge from in-hospital CPR. Our data reveal that the most vulnerable period was within 1 week after discharge, during which approximately 30% of all discharged survivors died. This phenomenon reminds us regarding the need for an electrophysiological examination before discharge from hospital for the purpose of secondary prevention of sudden cardiac death after discharge. Moreover, < 30% of cases were discharged with long-term tube dependency. Zimmerman et al. determined that requiring assisted living is already a major challenge of long-term care.[26] Overall, these findings highlight older survivors to discharge after in-hospital CPR continue to have a risk of death or functional decline.

Univariate analysis indicated that older age, higher Charlson–Deyo Comorbidity Index scores, and long-term tube dependency have a considerable negative impact on 1-year survival. Multivariate analysis indicated that requiring three medical tubes had the most significant effect among all factors on 1-year survival. Through adjusted Kaplan–Meier analysis comparing comorbidity model and cumulative effects of tube dependency, we also determined that the survival curve is strongly associated with the number of tubes. Although they did not focus only on older adults, several studies have highlighted that patients with long-term survival were those without the risk of anoxic brain damage or nursing home admission.[27–29] These results underscore the importance of functional independence for long-term survival. If possible, these patients should be provided education and training to be weaned off tube dependency to control chronic diseases. The fewer the number of tubes is, the lower is the mortality risk.

This study has some limitations. First, the retrospective observational design precluded detailed analysis of the CPR process. For example, we could not assess the patients' physical performance and quality of life before and after CPR. Second, because of database limitations, all cases older than 85 years were classified as ≥ 85 years old, so we could not consider the age factor as a continuous variable. Finally, details of some medical treatments were not available. However, the high volume of data in the national database can save the measure time and avoid incomplete follow-up bias. The new user design of our data can also decrease the possibility of prevalent user bias. Notably, our data are nationally representative, and the related clinical information about older adult CPR is not prone to recording error. In studies of rare events, this can prevent recall and selection bias caused by region or time selection. Moreover, the NHIRD is connected to file for Cause of Death Database, thus allowing the evaluation of every patient's real survival status after CPR.

In conclusion, survival rates of older adults after in-hospital CPR — either survival to discharge or long-term survival — appear to be generally low. Survival to discharge was higher in patients with a quick successful return of spontaneous circulation and VT- or VF-associated cardiac arrest and without nasogastric tube used before CPR and the main admission diagnosis of infection or cancer. Requiring three long-term medical tubes after CPR exhibited the highest negative impact on the prognosis of long-term survival apart from advanced age. Our findings remind health-care professionals to consider multiple aspects of efficacy and prognosis before administering CPR to make optimal decisions for hospitalized older patients.

Acknowledgments

The authors would like to thank Prof. Feng-Hwa Lu (former director of Institute of Gerontology, College of Medicine, National Cheng Kung University, Tainan, Taiwan) for his support with the de-

Table 4

Multivariate analysis of factors affecting 1-year nonsurvival among surviving older adults with noncritical discharge.

Variables	Model A OR (95% CI)	*p* values	Model B OR (95% CI)	*p* values	Model C OR (95% CI)	*p* values	Model D OR (95% CI)	*p* values
Age (ref :65–69)		0.028		0.029		0.017		0.018
70–74	1.135 (0.560–2.302)	0.337	1.133 (0.560–2.293)	0.367	1.208 (0.598–2.438)	0.334	1.216 (0.603–2.451)	0.229
75–79	1.055 (0.536–2.078)	0.155	1.021 (0.518–2.013)	0.131	1.132 (0.578–2.220)	0.168	1093 (0.556–2.147)	0.093
80–84	2.478 (1.222–5.024)	0.005	2.440 (1.203–4.950)	0.006	2.678 (1.325–4.409)	0.004	2.645 (1.308–5.349)	0.004
≥ 85	1.756 (0.845–3.647)	0.286	1.713 (0.825–3.557)	0.306	1.935 (0.943–3.972)	0.209	1.878 (0.915–3.856)	0.237
Sex (ref: female)								
Male	1.538 (1.011–2.342)	0.044	1.565 (1.003–2.326)	0.048	1.565 (1.030–2.381)	0.036	1.548 (1.017–2.352)	0.041
Charlson comorbidity index score								
By score *(0)			1.095 (1.007–1.191)	0.034			1.103 (1.012–1.202)	0.025
By group *(0)								
1–2	1.436 (0.692–2.982)	0.704			1.394 (0.672–2.889)	0.595		
3–4	1.934 (0.895–4.178)	0.192			1.924 (0.891–4.154)	0.196		
≥ 5	1.999 (0.794–5.029)	0.292			2.046 (0.812–5.154)	0.247		
Comorbidity (ref: non)								
Hypertension	0.977 (0.604–1.582)	0.926	0.941 (0.579–1.528)	0.806	0.958 (0.593–1.548)	0.861	0.914 (0.564–1.482)	0.716
Diabetes mellitus	1.148 (0.742–1.775)	0.535	1.157 (0.749–1.788)	0.510	1.153 (0.747–1.779)	0.520	1.170 (0.759–1.803)	0.478
Hyperlipidemia	0.689 (0.394–1.203)	0.190	0.753 (0.423–1.338)	0.333	0.704 (0.405–1.225)	0.215	0.779 (0.440–1.380)	0.391
COPD	0.838 (0.532–1.319)	0.445	0.897 (0.571–1.407)	0.635	0.855 (0.545–1.343)	0.497	0.911 (0.583–1.424)	0.683
Heart failure	0.700 (0.439–1.117)	0.135	0.717 (0.452–1.139)	0.159	0.697 (0.438–1.110)	0.129	0.715 (0.451–1.134)	0.154
CAD	1.117 (0.706–1.768)	0.636	1.143 (0.722–1.810)	0.567	1.079 (0.680–1.711)	0.748	1.098 (0.692–1.743)	0.692
Stroke	0.929 (0.593–1.456)	0.749	0.966 (0.620–1.506)	0.879	0.865 (0.553–1.353)	0.525	0.893 (0.574–1.389)	0.614
Dementia	0.986 (0.593–1.639)	0.956	1.075 (0.642–1.798)	0.784	0.910 (0.549–1.510)	0.715	0.991 (0.595–1.650)	0.971
Peptic ulcer disease	1.196 (0.734–1.948)	0.473	1.262 (0.780–2.042)	0.343	1.222 (0.751–1.991)	0.420	1.312 (0.810–2.126)	0.270
Malignancy	1.018 (0.569–1.821)	0.952	1.113 (0.624–1.987)	0.717	1.043 (0.583–1.864)	0.888	1.155 (0.648–2.058)	0.625
Renal disease	1.357 (0.819–2.248)	0.236	1.487 (0.910–2.429)	0.113	1.350 (0.811–2.249)	0.249	1.482 (0.906–2.424)	0.117
Post-CPR medical tube (ref: 0)								
Urinary catheter	1.533 (0.897–2.620)	0.118	1.549 (0.906–2.648)	0.110				
NG/gastrostomy/jejunostomy	1.328 (0.698–2.527)	0.382	1.276 (0.669–2.433)	0.460				
Tracheostomy	3.224 (1.826–5.691)	< 0.001	3.252 (1.841–5.743)	< 0.001				
Numbers of post-CPR medical tubes (ref: 0)								
1					2.453 (1.165–5.166)	0.536	2.703 (1.273–5.741)	0.730
2					4.056 (2.210–7.443)	0.084	4.159 (2.263–7.644)	0.088
3					6.818 (4.068–11.427)	< 0.001	6.758 (4.032–11.326)	< 0.001

CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CPR: cardiopulmonary resuscitation, NG: nasogastric.

Model A: The variables adjusted in the regression models were age, sex, comorbidity, by groups of Charlson comorbidity index score, post-CPR medical tube.

Model B: The variables adjusted in the regression models were age, sex, comorbidity, by scores of Charlson comorbidity index score, post-CPR medical tube.

Model C: The variables adjusted in the regression models were age, sex, comorbidity, by groups of Charlson comorbidity index score, numbers of post-CPR medical tubes.

Model D: The variables adjusted in the regression models were age, sex, comorbidity, by scores of Charlson comorbidity index score, numbers of post-CPR medical tubes.

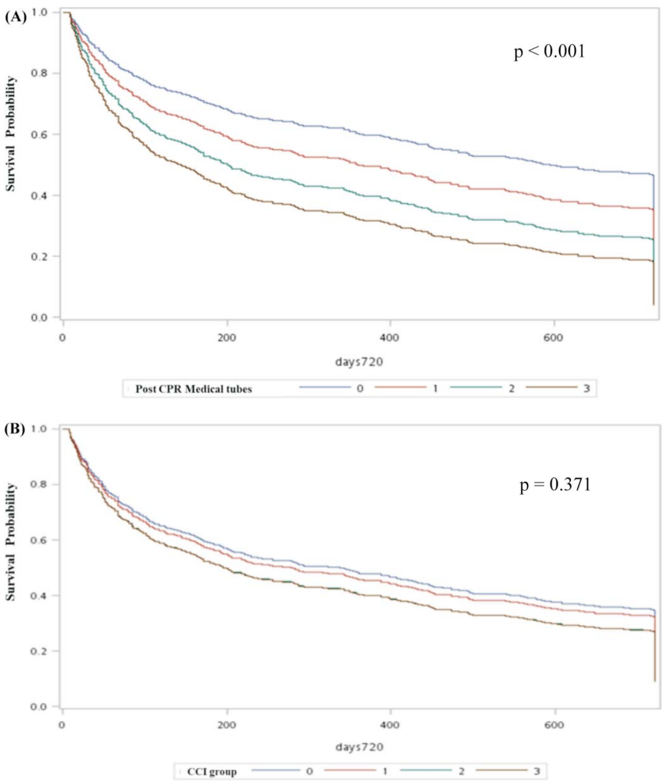

Figure 1. (A) Kaplan–Meier survival analysis by numbers of medical tubes, after adjustment for age and sex. Medical tubes included urinary catheter, nasogastric feeding tube, and tracheostomy tube. Post-CPR medical tubes: 0 = none and 1–3 = any one to all three tubes, respectively. (B) Kaplan–Meier survival analysis by CCI group after adjustment for age and sex. CCI group 0 = score 0, group 1 = score 1–2, group 2 = score 3–4, and group 3 = score ≥ 5.

velopment of the manuscript and provision of helpful comments.

This manuscript was edited by Wallace Academic Editing.

Additional information

We are grateful to the Health and Welfare Data Science Center, National Cheng Kung University Hospital, for providing administrative and technical support.

Funding source

This study was partially funded by National Cheng Kung University Hospital, Taiwan, under Grant NCKUH-10606003. The funding institution had no further role in the collection, analysis, and interpretation of data; the writing of this paper; or the decision to submit it for publication.

Competing interests

The authors declare no conflicts of interest.

Supplementary materials

Supplementary materials for this article can be found at http://www.sgecm.org.tw/ijge/journal/view.asp?id=36.

References

1. Girotra S, Spertus JA, Li Y, et al. Survival trends in pediatric in-hospital cardiac arrests: an analysis from Get With the Guidelines-Resuscitation. *Circ Cardiovasc Qual Outcomes*. 2013;6(1):42–49. doi:10.1161/CIRCOUTCOMES.112.967968
2. Girotra S, Nallamothu BK, Spertus JA, et al. Trends in survival after in-hospital cardiac arrest. *N Engl J Med*. 2012;367(20):1912–1920. doi:10.1056/NEJMoa1109148
3. van Gijn MS, Frijns D, van de Glind EM, C van Munster B, Hamaker ME. The chance of survival and the functional outcome after in-hospital cardiopulmonary resuscitation in older people: a systematic review. *Age Ageing*. 2014;43(4):456–463. doi:10.1093/ageing/afu035
4. Chan PS, Nallamothu BK, Krumholz HM, et al. Long-term outcomes in elderly survivors of in-hospital cardiac arrest. *N Engl J Med*. 2013;368(11):1019–1026. doi:10.1056/NEJMoa1200657
5. Stapleton RD, Ehlenbach WJ, Deyo RA, Curtis JR. Long-term outcomes after in-hospital CPR in older adults with chronic illness. *Chest*. 2014;146(5):1214–1225. doi:10.1378/chest.13-2110
6. Glavan BJ, Ehlenbach WJ. Long-term outcomes in elderly survivors of cardiac arrest. *N Engl J Med*. 2013;368(25):2437–2439. doi:10.1056/NEJMc1305198
7. Thapa SB, Kakar TS, Mayer C, Khanal D. Clinical outcomes of in-hospital cardiac arrest in COVID-19. *JAMA Intern Med*. 2021;181(2):279–281. doi:10.1001/jamainternmed.2020.4796
8. Schluep M, Gravesteijn BY, Stolker RJ, Endeman H, Hoeks SE. One-year survival after in-hospital cardiac arrest: A systematic review and meta-analysis. *Resuscitation.* 2018;132:90–100. doi:10.1016/j.resuscitation.2018.09.001
9. Cohen-Mansfield J, Brill S. After providing end of life care to relatives, what care options do family caregivers prefer for themselves? *PLoS One*. 2020;15(9):e0239423. doi:10.1371/journal.pone.0239423
10. Visvanathan A, Mead GE, Dennis M, Whiteley WN, Doubal FN, Lawton J. The considerations, experiences and support needs of family members making treatment decisions for patients admitted with major stroke: a qualitative study. *BMC Med Inform Decis Mak*. 2020;20(1):98. doi:10.1186/s12911-020-01137-7
11. Cheng CL, Kao YH, Lin SJ, Lee CH, Lai ML. Validation of the National Health Insurance Research Database with ischemic stroke cases in Taiwan. *Pharmacoepidemiol Drug Saf*. 2011;20(3):236–242. doi:10.1002/pds.2087
12. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45(6):613–619. doi:10.1016/0895-4356(92)90133-8
13. Sundararajan V, Henderson T, Perry C, Muggivan A, Quan H, Ghali WA. New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *J Clin Epidemiol*. 2004;57(12):1288–1294. doi:10.1016/j.jclinepi.2004.03.012
14. Valderas JM, Starfield B, Sibbald B, Salisbury C, Roland M. Defining comorbidity: implications for understanding health and health services. *Ann Fam Med*. 2009;7(4):357–363. doi:10.1370/afm.983
15. Huang YQ, Gou R, Diao YS, et al. Charlson comorbidity index helps predict the risk of mortality for patients with type 2 diabetic nephropathy. *J Zhejiang Univ Sci B*. 2014;15(1):58–66. doi:10.1631/jzus.B1300109
16. Murray SB, Bates DW, Ngo L, Ufberg JW, Shapiro NI. Charlson Index is associated with one-year mortality in emergency department patients with suspected infection. *Acad Emerg Med*. 2006;13(5):530–536. doi:10.1197/j.aem.2005.11.084
17. Yang LJ, Hsu SM, Wu PH, et al. Association of digoxin with mortality in patients with advanced chronic kidney disease: A population-based cohort study. *PLoS One*. 2021;16(1):e0245620. doi:10.1371/journal.pone.0245620
18. Adams DH, Snedden DP. How misconceptions among elderly patients regarding survival outcomes of inpatient cardiopulmonary resuscitation affect do-not-resuscitate orders. *J Am Osteopath Assoc*. 2006;106(7):402–404.
19. Doherty Z, Fletcher J, Fuzzard K, Kippen R, Knott C, O'Sullivan B. Short and long-term survival following an in-hospital cardiac arrest in a regional hospital cohort. *Resuscitation*. 2019;143:134–141. doi:10.1016/j.resuscitation.2019.08.028
20. Goldberger ZD, Chan PS, Berg RA, et al. Duration of resuscitation efforts and survival after in-hospital cardiac arrest: an observational study. *Lancet*. 2012;380(9852):1473–1481. doi:10.1016/S0140-6736(12)60862-9
21. Hirlekar G, Karlsson T, Aune S, et al. Survival and neurological outcome in the elderly after in-hospital cardiac arrest. *Resuscitation*. 2017;118:101–106. doi:10.1016/j.resuscitation.2017.07.013
22. Chavez-MacGregor M, Lei X, Zhao H, Scheet P, Giordano SH. Evaluation of COVID-19 mortality and adverse outcomes in US patients with or without cancer. *JAMA Oncol*. 2022;8(1):69–78. doi:10.1001/jamaoncol.2021.5148

23. Lee YF, Hsu TW, Liang CS, et al. The efficacy and safety of tube feeding in advanced dementia patients: A systemic review and meta-analysis study. *J Am Med Dir Assoc*. 2021;22(2):357–363. doi:10.1016/j.jamda.2020.06.035
24. Chan PS, Spertus JA, Kennedy K, et al. In-hospital cardiac arrest survival in the United States during and after the initial novel Coronavirus disease 2019 pandemic surge. *Circ Cardiovasc Qual Outcomes*. 2022;15(2):e008420. doi:10.1161/CIRCOUTCOMES.121.008420
25. Chauhan D, Varma S, Dani M, Fertleman MB, Koizia LJ. Nasogastric tube feeding in older patients: A review of current practice and challenges faced. *Curr Gerontol Geriatr Res*. 2021;2021:6650675. doi:10.1155/2021/6650675
26. Zimmerman S, Carder P, Schwartz L, et al. The imperative to reimagine assisted living. *J Am Med Dir Assoc*. 2022;23(2):225–234. doi:10.1016/j.jamda.2021.12.004
27. Jonsson H, Piscator E, Israelsson J, Lilja G, Djärv T. Is frailty associated with long-term survival, neurological function and patient-reported outcomes after in-hospital cardiac arrest? - A Swedish cohort study. *Resuscitation*. 2022;179:233–242. doi:10.1016/j.resuscitation.2022.07.013
28. Yonis H, Ringgren KB, Andersen MP, et al. Long-term outcomes after in-hospital cardiac arrest: 30-day survival and 1-year follow-up of mortality, anoxic brain damage, nursing home admission and in-home care. *Resuscitation*. 2020;157:23–31. doi:10.1016/j.resuscitation.2020.10.003
29. Andersen LW, Holmberg MJ, Berg KM, Donnino MW, Granfeldt A. In-hospital cardiac arrest: A review. *JAMA*. 2019;321(12):1200–1210. doi:10.1001/jama.2019.1696