

Public Health Burden of In-Hospital Cardiac Arrest

Paul Chan, MD

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Committee on Treatment of Cardiac Arrest: Current Status and Future Directions

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There are an estimated 200,000 in-hospital cardiac arrests (IHCA) each year in the U.S.¹ Until recently, data on outcomes of patients with IHCA was lacking. Since the launch of the American Heart Association's Get With The Guidelines (GWTG)-Resuscitation registry for IHCA in 2000, we have developed a better understanding of the processes of care and outcomes of patients with IHCA.

This report will provide contemporary data for adults with IHCA for year 2013. The analysis will be conducted using data from the GWTG-Resuscitation registry. Information on long term (post-discharge) outcomes will be provided using a sub-cohort, in which patient level data from this GWTG registry has been linked to Medicare inpatient files. Unless otherwise noted, results reflect GWTG-Resuscitation patient data from calendar year 2013 only, and provide unadjusted comparisons.

I. Etiology of Cardiac Arrest

Nearly 80% of IHCA occur in medicine wards and intensive care units (ICUs), whereas 1 in 5 occurs in surgical patients. Cardiac etiologies comprise 44% of all IHCA, whereas 56% of IHCA have non-cardiac etiologies. A breakdown of cardiac arrest etiology—overall and by survival to discharge status—is provided in the Table 1 below. Patients who arrest with a medical, non-cardiac etiology were less likely to survival to hospital discharge. Overall, 24.4% of all IHCA patients survived-to-discharge (4016/16,436=24.4), as shown in Table 1.

Table 1

	Survived to Discharge		Total N = 16,436	P-Value
	Yes n = 4016	No n = 12,420		
Etiology				< 0.001
Medical-Cardiac	1613 (40.2%)	4496 (36.2%)	6109 (37.2%)	
Medical-Noncardiac	1469 (36.6%)	6062 (48.9%)	7531 (45.9%)	
Surgical-Cardiac	454 (11.3%)	628 (5.1%)	1082 (6.6%)	
Surgical-Noncardiac	479 (11.9%)	1221 (9.8%)	1700 (10.4%)	
Missing	1	13	14	

II. Location of IHCA

Nearly half of all IHCAs in adults occur in hospital ICUs. Another 15% occur in telemetry wards and non-monitored wards each, while 1 in 8 IHCAs occur in emergency departments (Table 2). Patients with an IHCA in peri-procedural areas (comprising the majority of the ‘Other’ category) were the most likely to survive to hospital discharge, followed by patients with IHCAs on telemetry wards. In contrast, patients with an IHCA occurring in the ICUs and non-monitored units were the least likely to survive to discharge (Table 3).

Table 2

	Survived to Discharge		Total N = 16,436	P-Value
	Yes n = 4016	No n = 12,420		
Location				< 0.001
ICU	1596 (39.7%)	6427 (51.8%)	8023 (48.8%)	
Monitored Unit	723 (18.0%)	1741 (14.0%)	2464 (15.0%)	
Non-Monitored Unit	517 (12.9%)	1851 (14.9%)	2368 (14.4%)	
ER	553 (13.8%)	1491 (12.0%)	2044 (12.4%)	
Other	627 (15.6%)	906 (7.3%)	1533 (9.3%)	
Missing		4	4	
Monitored Arrest	2872 (71.5%)	9659 (77.8%)	12,531 (76.2%)	

Table 3

	Survived to discharge	Row Total (Denominator)	P-Value
	n = 4016	n = 16,436	
Location of Arrest			< 0.001
ICU	1596 (19.9%)	8023	
Monitored	723 (29.3%)	2464	
Non-Monitored	517 (21.8%)	2368	
ER	553 (27.1%)	2044	
Other	627 (40.9%)	1533	
Missing		4	

III. IHCA by Demographics

A. Age

The mean age for a patient with an IHCA was 65 ± standard deviation of 16 years. Table 4 below provides the distribution by age categories. Notably, 57% of all IHCA occur in patients younger than 70 years of age. Table 5 provides unadjusted rates of survival to hospital discharge by age category group, which are highest in patients under age 70 and lowest in those 80 years of age or older.

Table 4

	Survived to Discharge		Total N = 16,436	P-Value
	Yes n = 4016	No n = 12,420		
Age Category				< 0.001
18 to <50	679 (16.9%)	1879 (15.1%)	2558 (15.6%)	
50 to <60	831 (20.7%)	2046 (16.5%)	2877 (17.5%)	
60 to <70	1034 (25.7%)	2958 (23.8%)	3992 (24.3%)	
70 to <80	854 (21.3%)	2954 (23.8%)	3808 (23.2%)	
80 to <90	551 (13.7%)	2123 (17.1%)	2674 (16.3%)	
≥ 90	67 (1.7%)	460 (3.7%)	527 (3.2%)	
Age				< 0.001
Mean ± SD	63.3 ± 15.3	65.7 ± 16.0	65.1 ± 15.9	
Median (IQR)	64.0 (54.0, 74.0)	67.0 (56.0, 78.0)	66.0 (56.0, 77.0)	

Table 5

	Survived to discharge		Row Total	P-Value
	n = 4016	(Denominator) n = 16,436	n = 16,436	
Age				< 0.001
18 to <50	679 (26.5%)		2558	
50 to <60	831 (28.9%)		2877	
60 to <70	1034 (25.9%)		3992	
70 to <80	854 (22.4%)		3808	
80 to <90	551 (20.6%)		2674	
≥ 90	67 (12.7%)		527	
Sex				0.935
Male	2363 (24.5%)		9663	
Female	1652 (24.4%)		6771	
Missing	1		2	

B. Gender and Race

Table 6 below depicts the distribution of IHCAs by race and gender. Nearly 3 in 5 IHCAs occur in men, and 24% occurs in patients of black race (Table 6). Unlike results from prior years², rates of overall survival were similar between men and women in 2013 (see prior Table 5). Consistent with other years, rates of survival to discharge were significantly higher among patients of white race (Table 7).³ Finally, there were no differences in rates of survival for patients of Hispanic and non-Hispanic ethnicity

Table 6

	Survived to Discharge		Total N = 16,436	P-Value
	Yes n = 4016	No n = 12,420		
Sex				0.605
Male	2363 (58.8%)	7300 (58.8%)	9663 (58.8%)	
Female	1652 (41.1%)	5119 (41.2%)	6771 (41.2%)	
Unknown	1 (0.0%)	1 (0.0%)	2 (0.0%)	
Race				< 0.001
White	2926 (72.9%)	8369 (67.4%)	11,295 (68.7%)	
Black	805 (20.0%)	3062 (24.7%)	3867 (23.5%)	
Other	68 (1.7%)	223 (1.8%)	291 (1.8%)	
Unknown	217 (5.4%)	766 (6.2%)	983 (6.0%)	
Hispanic Ethnicity	174 (4.3%)	562 (4.5%)	736 (4.5%)	0.60
Missing	12	50	62	

Table 7

	Survived to discharge		Row Total (Denominator)	P-Value
	n = 4016	n = 16,436		
Race				< 0.001
White	2926 (25.9%)	11295		
Black	805 (20.8%)	3867		
Other	68 (23.4%)	291		
Unknown	217 (22.1%)	983		
Hispanic				0.60
Yes	174 (23.6%)	736		
No	3830 (24.5%)	15638		
Missing	12	62		

IV. Initial Cardiac Arrest Rhythm

The vast majority of IHCA (82.6%) were not amenable to defibrillation treatment, with asystole comprising 28% and pulseless electrical activity (PEA) 54.6% of all IHCAs (Table 8). One in 10 patients had a first reported cardiac arrest rhythm of ventricular fibrillation (VF) and 7.4% with pulseless ventricular tachycardia (VT). Overall survival for VF and pulseless VT, however, was more than double that for IHCAs due to asystole and PEA (Table 9).

Table 8

	Survived to Discharge		Total N = 16,436	P-Value
	Yes n = 4016	No n = 12,420		
Initial Arrest Rhythm				< 0.001
Asystole	929 (23.1%)	3669 (29.5%)	4598 (28.0%)	
PEA	1779 (44.3%)	7192 (57.9%)	8971 (54.6%)	
VF	759 (18.9%)	885 (7.1%)	1644 (10.0%)	
Pulseless VT	549 (13.7%)	674 (5.4%)	1223 (7.4%)	
Shockable Rhythm	1308 (32.6%)	1559 (12.6%)	2867 (17.4%)	< 0.001

Table 9

	Survived to discharge		Row Total	P-Value
	n = 4016	n = 16,436	(Denominator) n = 16,436	
Initial Cardiac Arrest Rhythm				< 0.001
VF	759 (46.2%)	1644		
Pulseless VT	549 (44.9%)	1223		
Asystole	929 (20.2%)	4598		
PEA	1779 (19.8%)	8971		
Rhythm Type				< 0.001
Shockable	1308 (45.6%)	2867		
Non-Shockable	2708 (20.0%)	13569		

V. Survival by U.S. Geographical Region

Overall rates of IHCA survival were highest in the North Central and Mountain Pacific U.S. census regions and lowest in the South Central region (Table 10).

Table 10

	Survived to discharge n = 4016	Row Total (Denominator) n = 16,436	P-Value
U.S. Census Region			< 0.001
North Mid-Atlantic	548 (24.1%)	2270	
South Atlantic	794 (23.4%)	3399	
North Central	697 (27.9%)	2501	
South Central	671 (22.9%)	2925	
Mountain Pacific	379 (26.0%)	1460	
Missing	927	3881	

VI. Survival by Hospital Characteristics

For adults with IHCA during 2013, there were no significant differences in overall survival by hospital teaching status or rural status (Table 11).

Table 11

	Survived to discharge n = 4016	Row Total (Denominator) n = 16,436	P-Value
Teaching Status of Hospital			0.097
Major teaching	1554 (25.0%)	6215	
Minor teaching	733 (23.2%)	3162	
Non-teaching	802 (25.2%)	3178	
Not Available	927	3881	
Is Hospital Rural or Urban?			0.93
Rural	106 (24.4%)	434	
Urban	2983 (24.6%)	12121	
Not Available	927	3881	

VII. Survival by AED Use

Among 8413 patients with an IHCA outside the ICU in 2013, about 1 in 3 was evaluated with an AED. Consistent with prior studies⁴, there was a trend in 2013 toward lower survival among non-ICU patients initially evaluated with an AED (Table 12).

Table 12

	Survived to discharge n = 2420	Row Total (Denominator) n = 8413	P-Value
AED use (non-ICU pts only)			0.11
Yes	792 (27.7%)	2862	
No	1627 (29.4%)	5542	
Missing	1	9	

VIII. Time of Day and Week for IHCA

Approximately half of all IHCAs occurred between 7:00 am and 10:59 pm during weekdays, whereas half occurred between 11:00 pm and 6:59 am during weekdays or anytime during weekends. Consistent with prior research⁵, IHCA survival was markedly higher among patients with weekday daytime arrests. Notably, overall survival was similar between weekday night time arrests and weekend arrests (Table 13).

Table 13

	Survived to discharge n = 4016	Row Total (Denominator) n = 16,436	P-Value
Day and Time of Arrest			< 0.001
Daytime	2228 (27.5%)	8102	
Night time	567 (20.7%)	2735	
Weekend	1144 (21.3%)	5367	
Missing	77	232	

IX. Temporal Survival Trends

Please note: The following analyses incorporates all data collected within GWTG-Resuscitation between 2000 and 2013.

A prior study has previously reported significant improvements in survival for IHCA within GWTG-Resuscitation, from 16.2% in 2000 to 21.8% in 2009.⁶ We found that this improved trend has continued since then, with unadjusted survival rates increasing further to 24.4% in 2013 (Table 14).

Table 14

Year	Survived to Discharge	Total	P-Value
	n = 35,149	(Denominator) n = 169,619	
			< 0.001
2000	362 (16.2%)	2233	
2001	1108 (18.3%)	6048	
2002	1775 (17.7%)	10014	
2003	2265 (17.5%)	12947	
2004	2579 (18.7%)	13806	
2005	2662 (19.0%)	14030	
2006	2679 (19.3%)	13915	
2007	2726 (19.7%)	13840	
2008	3025 (21.4%)	14137	
2009	3015 (21.8%)	13842	
2010	2676 (23.0%)	11625	
2011	2912 (23.5%)	12416	
2012	3296 (23.0%)	14330	
2013	4016 (24.4%)	16436	

The increased survival trend occurred in both shockable and non-shockable cardiac arrest rhythms. For patients with an initial cardiac arrest rhythm of VF or pulseless VT, survival has increased from 34.0% in 2000 to 45.6% in 2013 (Table 15). Similarly, survival has essentially doubled from 2000 to 2013 for patients with an initial cardiac arrest of asystole or PEA (Table 16).

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Table 15: VF and Pulseless VT

	Survived to discharge n = 14,264	Total (Denominator) n = 35,086	P-Value
Year			< 0.001
2000	253 (34.0%)	745	
2001	630 (36.2%)	1741	
2002	908 (36.9%)	2459	
2003	1167 (38.3%)	3047	
2004	1255 (39.1%)	3209	
2005	1256 (39.9%)	3144	
2006	1182 (40.0%)	2955	
2007	1114 (39.2%)	2843	
2008	1131 (41.6%)	2722	
2009	1133 (43.2%)	2621	
2010	888 (44.2%)	2007	
2011	984 (43.1%)	2284	
2012	1035 (42.4%)	2442	
2013	1308 (45.6%)	2867	

Table 16: Asystole and PEA

	Survived to discharge n = 20,885	Total (Denominator) n = 134,533	P-Value
Year			< 0.001
2000	109 (7.3%)	1488	
2001	478 (11.1%)	4307	
2002	867 (11.5%)	7555	
2003	1098 (11.1%)	9900	
2004	1324 (12.5%)	10597	
2005	1406 (12.9%)	10886	
2006	1497 (13.7%)	10960	
2007	1612 (14.7%)	10997	
2008	1894 (16.6%)	11415	
2009	1882 (16.8%)	11221	
2010	1788 (18.6%)	9618	
2011	1928 (19.0%)	10132	
2012	2261 (19.0%)	11888	
2013	2708 (20.0%)	13569	

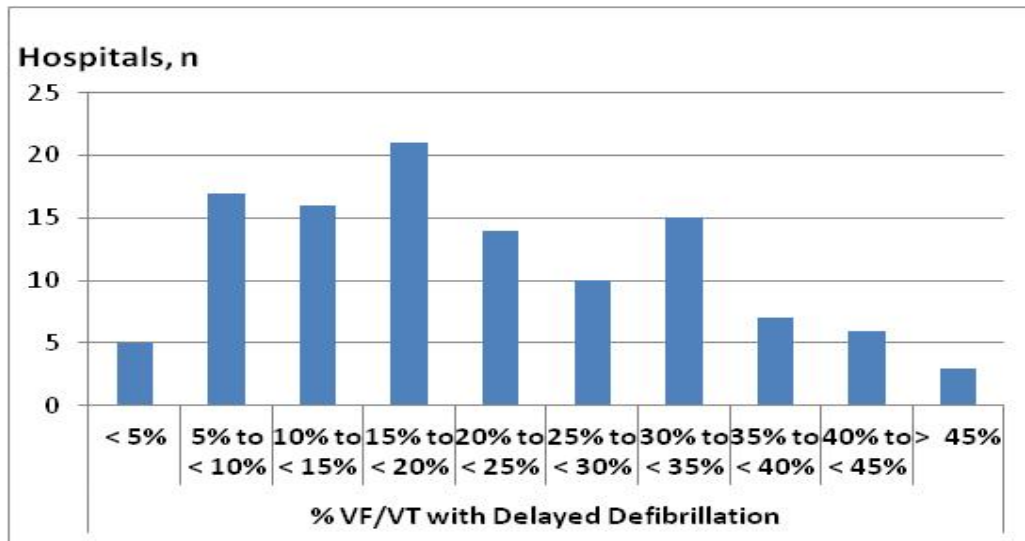
X. Defibrillation Time

Defibrillation times for cardiac arrests due to VF or pulseless VT during 2013 are described in Table 17. The mean and median times to defibrillation were 2 minutes and 1 minute, respectively. Delays in defibrillation, which have been linked to lower survival⁷, were recorded for 27% of shockable IHCAs. Among sites with ≥ 10 treated cases, there remained significant variation in hospital rates of delayed defibrillation (Figure 1).

Table 17

	Total n = 2867
Time to defibrillation (minutes)	
Mean \pm SD	2.1 \pm 3.1
Median (IQR)	1.0 (0.0, 3.0)
Missing	634
Time to defibrillation by minute	
0 to <1	931 (41.7%)
1	350 (15.7%)
2	350 (15.7%)
3	165 (7.4%)
4	110 (4.9%)
5	82 (3.7%)
6 or greater	245 (11.0%)
Missing	634
Delayed Defibrillation (> 2 min.)	
Yes	602 (27.0%)
No	1631 (73.0%)
Missing	634

Figure 1



XI. Time to CPR

Most patients with an identified IHCA had cardiopulmonary resuscitation (CPR) begun promptly (Table 18). Only 5% of cases had significant delays in the initiation of CPR of 1 minute or greater upon recognition of cardiac arrest in a hospitalized patient.

Table 18

	Survived to discharge			P-Value
	Yes n = 4016	No n = 12420	Total n = 16,436	
Time to CPR by minutes				0.001
0 to <1	3560 (94.3%)	11468 (95.5%)	15028 (95.2%)	
1 to <2	146 (3.9%)	337 (2.8%)	483 (3.1%)	
2 to <3	37 (1.0%)	107 (0.9%)	144 (0.9%)	
3 to <4	16 (0.4%)	19 (0.2%)	35 (0.2%)	
4 to <5	6 (0.2%)	16 (0.1%)	22 (0.1%)	
5 to <6	5 (0.1%)	27 (0.2%)	32 (0.2%)	
6 to 20	7 (0.2%)	30 (0.2%)	37 (0.2%)	
Missing (.)	239	416	655	

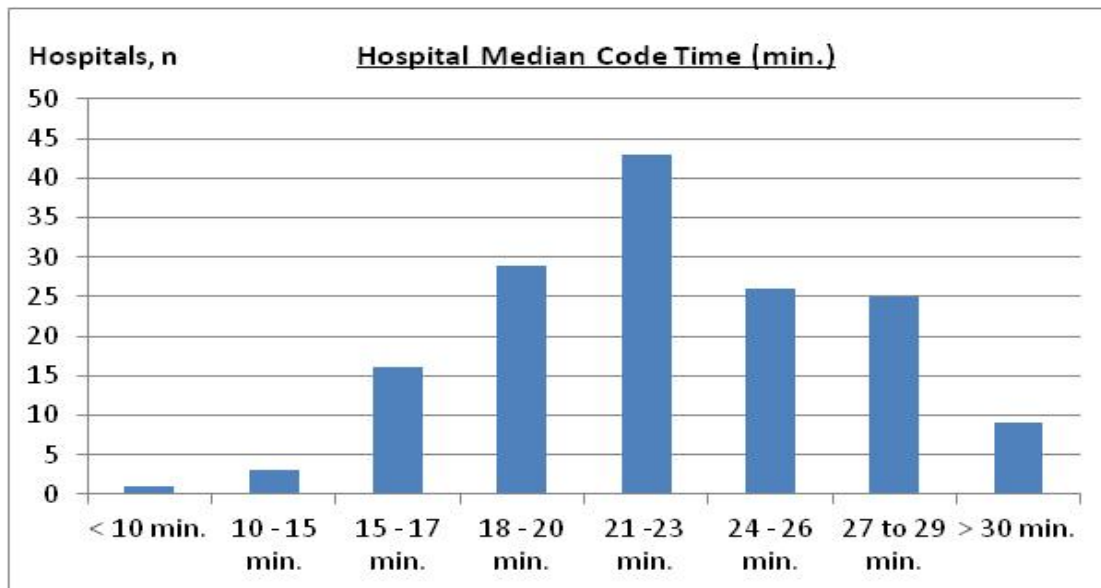
XII. Code Duration

In prior work, investigators have found that hospitals with more aggressive resuscitation times for IHCA (indirectly assessed as the average code duration among patients who did not achieve ROSC at a site) had higher overall rates of IHCA survival.⁸ Resuscitation duration for patients who did and did not achieve ROSC in 2013 are summarized below. Although most patients who survived the initial code achieved ROSC within the first 20 minutes, 13% of patients did not achieve ROSC until at least 20 minutes of resuscitation had been administered. However, among patients who did not achieve ROSC, 40% had code durations of <20 minutes. Notably, there was significant variation across sites in median code duration among patients who did not achieve ROSC (Figure 2).

Table 19

Duration of resuscitation (minutes)	Code Duration	
	ROSC n = 11,469	No ROSC n = 4873
0 to <5	3347 (30.3%)	172 (4.0%)
5 to <10	3412 (30.9%)	324 (7.6%)
10 to <15	1873 (16.9%)	550 (12.9%)
15 to <20	988 (8.9%)	662 (15.5%)
20 to <25	532 (4.8%)	718 (16.8%)
25 to <30	294 (2.7%)	591 (13.9%)
30 to 90	613 (5.5%)	1249 (29.3%)
Missing	410	607

Figure 2



XIII. Long Term Outcomes Among Survivors

For the following analyses, data from GWTG-Resuscitation between 2000 and 2012 were linked with Medicare beneficiary files during the same time period. A total of 56,574 patients aged 65 and older were linked with Medicare files. We then restricted the analyses to only those patients who survived to hospital discharge, thus leaving 10,367 Medicare-matched patients who survived to hospital discharge after an IHCA.

A. Long Term Survival

For survivors of IHCA who were 65 years of age or older, the overall survival rate was 65.4% at 6-months, 58.4% at 1-year, 49.5% at 2-years, 43.6% at 3-years, 38.2% at 4-years, and 33.4% at 5 years. Table 20 below describes long-term survival by initial cardiac arrest rhythm, Table 21 by discharge disposition, and Table 22 by discharge neurological status. Patients with an shockable initial cardiac arrest rhythm, who were discharged home, or had little to no neurological disability at the time of hospital discharge had the highest long-term survival rates.

Table 20

Cardiac Arrest Rhythm	0.5 yr	1 yr	1.5 yrs	2 yrs	2.5 yrs	3 yrs	3.5 yrs	4 yrs	4.5 yrs	5 yrs
Asystole	60.4%	54.4%	49.1%	44.8%	41.5%	38.6%	35.5%	33.0%	30.5%	28.2%
PEA	58.2%	50.0%	45.4%	41.7%	38.5%	36.0%	32.9%	30.6%	28.2%	26.4%
VF	76.1%	69.7%	66.0%	61.9%	58.5%	56.2%	53.8%	51.5%	49.3%	46.0%
Pulseless VT	69.7%	62.2%	56.0%	51.6%	48.5%	44.8%	41.1%	38.1%	35.3%	33.0%

Table 21

Discharge Disposition	0.5 yr	1 yr	1.5 yrs	2 yrs	2.5 yrs	3 yrs	3.5 yrs	4 yrs	4.5 yrs	5 yrs
Home	83.5%	77.6%	72.2%	67.7%	64.4%	61.4%	58.4%	55.7%	52.7%	50.1%
Skilled Nursing /Rehab	59.6%	51.2%	46.4%	42.2%	38.7%	35.8%	32.6%	30.1%	27.9%	25.3%
Hospice	7.4%	5.8%	5.0%	4.8%	4.5%	4.5%	4.1%	3.3%	3.0%	3.0%

Table 22

Neurological Disability	0.5 yr	1 yr	1.5 yrs	2 yrs	2.5 yrs	3 yrs	3.5 yrs	4 yrs	4.5 yrs	5 yrs
CPC of 1 (little to none)	79.0%	72.6%	68.0%	63.9%	60.6%	57.8%	54.3%	51.7%	49.1%	46.6%
CPC >1	52.4%	44.8%	40.3%	36.0%	32.8%	30.1%	27.4%	25.2%	23.1%	20.8%

B. Long-Term Readmission

The cumulative readmission incidence among Medicare-aged survivors of IHCA was 35 admissions per 100 patient-years at 1 month, 186 admissions per 100 patient-years at 6 months, and 371 admissions per 100 patient-years at 3-years.

Table 23 below compares cumulative readmission rates within subgroups. Compared to patients with an initial cardiac arrest rhythm of asystole, patients with an initial arrest rhythm of PEA had a 9% higher cumulative readmission rate, where those with an initial cardiac arrest rhythm of VF had a 19% lower cumulative readmission rate. Patients who were discharged to a skilled nursing or rehabilitation facility had a higher cumulative readmission rate than those sent home. Finally, patients with mild to no neurological disability at discharge had markedly higher long-term survival.

Table 23

	Hazard Ratio	<i>P value</i>
Initial Cardiac Arrest Rhythm		
Asystole	Reference	Reference
PEA	1.09 (1.01-1.17)	0.02
VF	0.81 (0.75-0.87)	<0.001
Pulseless VT	1.00 (0.92-1.09)	0.97
Discharge Disposition		
Home	Reference	Reference
Nursing or Rehab Facility	1.40 (1.32-.47)	<0.001
Hospice	1.05 (0.78-1.40)	0.75
Discharge Neurological Status		
CPC of 1	Reference	Reference
CPC >1	1.36 (1.29-1.44)	<0.001

C. One-Year Inpatient Costs

Inpatient costs at 1-year after hospital discharge are summarized in Table 24 by initial cardiac arrest rhythm, discharge disposition, and discharge neurological status. Generally, patients with an initial non-shockable cardiac arrest rhythm of asystole or PEA, who were not discharged home, or had significant neurological disability, had higher long-term inpatient costs.

Table 24

	N	Mean	Median
Initial Cardiac Arrest Rhythm			
Asystole	2566	\$15,159	\$3,268
PEA	3379	\$17,145	\$4,028
VF	2794	\$12,879	\$3,444
Pulseless VT	1590	\$13,964	\$4,599
Discharge Disposition			
Home	4908	\$12,553	\$3,813
Nursing or Rehab Facility	2810	\$14,254	\$6,803
Discharge Neurological Status			
CPC of 1	4463	\$14,077	\$4,083
CPC >1	4225	\$15,675	\$3,904

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