Variability in functional outcome and treatment practices by treatment center after out-of-hospital cardiac arrest: Analysis of International Cardiac Arrest Registry

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Abstract:

Purpose: Functional outcomes vary between centers after out of hospital cardiac arrest (OHCA) and are partially explained by preexisting health status and arrest characteristics, while the effects of in-hospital treatments on functional outcome are less understood. We examined variation in functional outcomes by center after adjusting for patient and arrest-specific characteristics and evaluated how in-hospital management differs between high and low performing centers.

Methods: Analysis of observational registry data within the International Cardiac Arrest Registry (INTCAR) was used to perform a hierarchical model of center-specific risk standardized rates for good outcome, adjusted for demographics, pre-existing functional status, arrest related factors with treatment center as a random effect variable. We described the variability in treatments and diagnostic tests that may influence outcome at centers with adjusted rates significantly above and below registry average.

Results: 3855 patients admitted to an ICU following cardiac arrest with return of spontaneous circulation. The overall prevalence of good outcome was 11-63% among centers. After adjustment, center-specific risk standardized rates for good functional outcome ranged from 0.47 (0.37-0.58) to 0.20 (0.12-0.26). High performing centers had faster time to goal temperature, were more likely to have goal temperature of 33°C, more likely to perform unconscious cardiac catheterization and percutaneous coronary intervention, and had differing prognostication practices that low performing centers.

Conclusions: Center-specific differences in outcomes after OHCA after adjusting for patient-specific factors exist. This variation could partially be explained by in-hospital management differences. Future research should address the contribution of these factors to the differences in outcomes after resuscitation.

'Take Home Message':
There are significant center-specific differences in outcomes after out of hospital cardiac arrest after adjusting for patient-specific factors. These differences are partially explained by in-hospital treatment decisions.

Tweet:
Largest study evaluating center-specific outcomes for out-of-hospital cardiac arrest; finding significant center-specific differences after adjustment

98   Introduction

99   Functional outcome of patients who survive out-of-hospital cardiac arrest (OHCA) and receive in-hospital care are

100   determined in part by their underlying health status and arrest-specific factors, but many aspects of medical care

101   after cardiac arrest may influence outcomes as well[1-5]. Reporting of cardiac arrest outcomes specific to individual

102   hospitals is increasing, but at this time there is no risk-adjustment standard to benchmark hospital performance [6].

103   Post-resuscitation care varies widely between centers, including many practices associated with outcome such as

104   targeted temperature management (TTM), utilization of coronary angiography and percutaneous coronary

105   intervention (PCI), mechanical circulatory support, glucose control, oxygenation and ventilation practices, blood

106   pressure management, sedation regimes and prognostication practices [4, 5, 7-9]. Some of these management

107   strategies align with the volume of patients cared for at a given center [9-11]. Given these inconsistencies and the

108   medical complexity of these high-risk patients and the need for urgent triage, an improved understanding of which

109   in-hospital treatment options and interventional strategies may affect outcomes is needed. The ability to risk-adjust

110   overall outcome by center is an important first step, enabling identification of modifiable differences between

111   management strategies.

112   Patient and arrest-specific risk factors for poor outcome following cardiac arrest have been described [12-17], but

113   few studies have reported center outcomes adjusted for risk using patient-level data[7, 8] or identified in-hospital

114   factors that may explain variation between centers. We sought to develop a risk-adjustment model to evaluate

115   between-center effects of functional outcome at hospital discharge in patients with OHCA who received TTM as an

116   initial step to identify potential in-hospital treatment variation that might explain such differences. We also explored

117   variation in various treatment modalities and diagnostic tests that may potentially explain some of the differences in

118   outcomes between high and low performing centers[18].

119

120   Methods:

121   *Data source*

122   The International Cardiac Arrest Registry (INTCAR) is a multicenter, international database of United States and

123   European centers including both in-hospital and out-of-hospital cardiac arrest patients. The registry began enrolling

124   patients in 2006 and as of November 2017, included 6010 patients from 42 hospitals. Centers enrolled consecutive

125   adult patients admitted to an intensive care unit after cardiac arrest. Management of patients was at the discretion of

126 the treating center, according to local best practices. Centers participated in the registry on a voluntary basis, there

127 was no reimbursement for enrolling patients, and all had institutional review board approval at their center. We

128 included patients from the INTCAR registry with OHCA enrolled between the years 2006 and 2017, and excluded

129 centers that enrolled less than 25 patients. The INTCAR registry consists of two sequential and non-overlapping

130 iterations; a 1.0 dataset (years of 2006-2011) and a 2.0 dataset (years 2011-2017); we combined these data sets and

131 included variables found in both. INTCAR data encompassed the Utstein data points[19] as well as many in-hospital

132 variables related to post-resuscitation care[14]. Although centers enrolled consecutive adult patients with both in-

133 hospital (IHCA) and out-of-hospital cardiac arrest (OHCA), only patients with OHCA were included in this

134 analysis.

135 *Outcome:*

136 The primary outcome was the Cerebral Performance Category (CPC) score at hospital discharge. Consistent with

137 previous reporting in large clinical trials, CPC was dichotomized into good outcome (normal to moderate cerebral

138 disability: CPC 1-2) and poor outcome (severe cerebral disability to brain death: CPC 3-5)[2, 20, 21]. The time point

139 of hospital discharge was chosen because longer-term outcome is influenced by factors other than hospital care,

140 including post-discharge services, insurance status, and various comorbidities, which was not recorded in the

141 registry [22-24]. Secondary outcome was delayed CPC which is typically determined at 6 months either by review

142 of medical records or a telephone call.

143 *Predictors*:

144 Candidate variables from both the 1.0 and 2.0 database included age, sex, pre-arrest CPC, past medical history

145 [composite endpoint of chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), arrhythmia,

146 congestive heart failure (CHF), hypertension, chronic kidney disease, liver disease, obesity, malignancy, renal

147 disease, non-insulin dependent diabetes mellitus (NIDDM), insulin dependent diabetes mellitus (IDDM)], initial

148 rhythm (shockable versus non-shockable), time to return of spontaneous circulation (ROSC) (including both no-flow

149 and low-flow time), bystander cardiopulmonary resuscitation (CPR), witnessed arrest, and defibrillation.

150 *In-hospital factors:*

151 In-hospital factors available between the two datasets included several temperature-related events, including target

152 temperature (32-34°C, 35-36°C, 37°C or greater), time to initiation of target temperature, and post-temperature

153 management fever. The utilization of cardiac interventions and hemodynamic support were analyzed, including

154   cardiac catheterization, percutaneous intervention, and coronary artery bypass grafting occurring while the patient

155   remained unconscious, while they were awake, or not performed (analyzed for all patients, patients with known ST-

156   elevation myocardial infarction on ECG, and those with a shockable rhythm), thrombolysis and intra-aortic balloon

157   pump use. Utilization of diagnostic tests used to guide neurologic care and prognostication were evaluated,

158   including use of electroencephalogram (EEG), continuous electroencephalogram (cEEG), magnetic resonance

159   imaging (MRI), computed tomography (CT), and somatosensory evoked potential (SSEP). Early withdrawal of life

160   support was evaluated as patients who had both withdrawal of life sustaining therapies and an ICU length of stay of

161   three days or less.

162   *Missing data:*

163   The effect of missing data was assessed with each explanatory and outcome variable. The distribution of the model

164   variables was compared between patients with complete and incomplete data to verify that the population of patients

165   with missing data was similar.

166   *Statistical analysis:*

167   Continuous variables were assessed for linearity of response on outcome and categorized if needed due to

168   nonlinearity. The relationship of candidate variables with outcome was initially assessed in a univariate manner

169   using logistic regression; these were retained in the model if the p-value was < 0.20. The decision was made *a priori*

170   to force three selected variables into the model (time to ROSC, age, initial shockable rhythm), regardless of

171   statistical significance, based on prior evidence suggesting significant prognostic value [25-28]. A hierarchical

172   logistic regression model for good outcome as a function of patient demographic and clinical variables was created

173   with a random center-specific effect. Performance was assessed using area under the Receiver Operator

174   Characteristic (ROC) curve and likelihood ratio tests to predict good outcome. The model was then used to calculate

175   risk-standardized good functional outcome rates based on "Method 3" described in a comparison of national risk

176   adjustment[29]. This was done by first by finding the predicted outcome of each patient within each center

177   (predicted outcome) then measuring the expected rate of outcome at each facility, given the predicted probability for

178   outcome for patients at that center (expected outcome). The risk adjusted ratio was calculated as the registry average

179   outcome multiplied by the ratio of observed and expected outcomes. This approach allows for control of clustering

180   among the 25 centers by calculating a center-specific intercept within the model. Risk-standardized mortality rates

181   were then calculated as the observed rate divided by the expected rate at each center where the expected rate is the

182   predicted rate from the hierarchical logistic regression model substituting a null center effect. Thus the risk

183   standardized rate using this approach allows for adjustment based on patient mix for each center and simultaneously

184   allows for shrinkage due to center clustering. This methodology of risk adjustment increases content validity

185   compared to classic logistic regression based modeling and has higher convergent validity compared to shrinkage

186   estimator-based risk-adjustment[29]. The analysis was repeated using the subgroup of patient who met Utstein

187   comparator criteria (shockable rhythm, received bystander CPR, and arrest was witnessed).

188   We then evaluated 'high' and 'low' performing centers defined as risk-standardized ratio confidence intervals

189   significantly above or below the registry average. These were pooled into high and low groups and in-center

190   resource utilization was compared. Factors found to be statistically significant between high and low performing

191   groups were then added into the full model and evaluated for improvement in model performance using ROC curves

192   and evaluation of Akaike information criterion.

193   Results

194   *Patient population*

195   The INTCAR registry data included 6010 patients from 42 centers and 4544 patients had OHCA. Three thousand

196   eight hundred fifty five patients from 25 centers had complete data and enrolled at least 25 patients (Table 1). The

197   average age of this study population was 61 years (±15 years), 31% were female, 53% of patients had an initial

198   shockable rhythm, and the average time to ROSC was 26 (±18) minutes. 34% achieved good functional outcome at

199   hospital discharge. Influence of individual components of past medical history are shown in supplement table 1.

200

201   *Missing data*

202   There were 420 patients with non-complete data. The variable most missing was time to ROSC, absent in 6% of

203   cases. The second most often missing variable was outcome at hospital discharge, absent in 1.6% of cases. A

204   sensitivity analysis was performed to compare patients with and without missing data, which revealed similar age

205   (60 ±17 years vs 61± 15 years, p=0.09) and time to return of spontaneous circulation (26± 24 minutes vs 26 ±18

206   minutes, p=0.76). There was a difference in incidence of initial shockable rhythm (46% vs 53%, p=0.007) for

207   missing and nonmissing data, respectively. Within the group of patients with missing data, 253 (60%) were missing

208   the variable for ROSC and 288 (67%) were unwitnessed. The outcome of good CPC at hospital discharge was 30%

209   for patients with missing data and 34% for patients without missing data (p=0.21). Multiple imputation was

210   performed with similar results in the multivariable model, with the exception of age (Supplement table 2).

211   *Model development*

212   Univariate and multivariate analysis of all candidate variables are shown in Table 2. Linearity with outcome was

213   assessed for age and time to ROSC. The relationship between time to ROSC and the primary outcome was found to

214   be nonlinear, therefore categorized by five-minute intervals and referenced to the largest subgroup (15-20 minutes).

215   Age, sex, number of medical diagnoses, initial rhythm, time to ROSC, witnessed arrest, bystander CPR, and

216   defibrillation were found to be statistically significant predictors of outcome and were retained in the model..

217   *Outcome by Center after Risk Adjustment*

218   The unadjusted frequency of a good functional outcome at hospital discharge ranged from 11%-63% with a center-

219   mean of 39% among the 25 centers. The risk-standardized outcome rate ranged from 20% (CI 12%- 27%) to 50%

220   (CI 39%- 61%). The distribution following adjustment is shown in figure 1. When limited to centers with

221   confidence intervals that did not overlap the registry average, four high performing centers were significantly above

222   average, with a range of 40% to 50% of risk adjusted good outcome by center, and an average for the group of 44%.

223   Similarly, five low performing centers were significantly below the average, with a range of 20% to 27% risk

224   adjusted good outcome by center and an average for the group of 24% (Figure 1). Observed, predicted, expected

225   rates of good outcome at hospital discharge and values of risk adjusted ratio are shown in supplement table 3.

226   For the secondary outcome of delayed CPC at the Registry average of 6 months, the unadjusted frequency of good

227   functional outcome at an average of six months ranged from 0%-54% with a center-mean of 35% among the 25

228   centers. The risk-standardized outcome rate ranged from 0 (CI 0%-13%) to 54% (CI 42%-65%). Following

229   adjustment, four centers performed significantly better than the registry average and five centers performed

230   significantly worse than registry average (Figure 2). Observed, predicted, expected rates of good outcome at six

231   months and values of risk adjusted ratio are shown in supplement table 4.

232   *Characteristics of high versus low performing centers*

233   Patient characteristics and in-hospital resource utilization were compared between high- and low-performing centers

234   (Table 3). Treatment variables that were significantly different between high and lower performing centers included

235   time to start of target temperature, TTM target goal, use of cardiac catheterization and PCI while patients were

236   unconscious (for patients with STEMI, shockable rhythm, and all patients) and use of thrombolysis. Of patients with

7

237   a poor outcome, the use of prognostication variables differed with the use of continuous EEG, MRI, and SSEP.

238   Withdrawal of life sustaining therapies within the first three days were more common in the high performing centers

239   (194 patients (23%) versus 181 patients (15%), p<0.001) (supplement table 5). There was no difference between

240   higher and lower performing centers in the incidence of fever in the first 72 hours, diagnosis of pneumonia, use of

241   intra-aortic balloon pump, or treatment by coronary artery bypass grafting (CABG). Adding these significant

242   variables to the model resulted in only a modest improvement AUC (0.84 to 0.89) and a lower Akaike information

243   criterion, suggesting these treatment factors only modestly improve model performance (Figure2).

244   *Utstein Comparator Subgroup*

245   A total of 1296 patients (25% of cohort) met criteria of having a shockable rhythm, receiving bystander CPR, and

246   having a witnessed arrest. The incidence of good outcome was higher than the full cohort, at 57.3%. High and low

247   performing centers were similar (in low performing group, one was no longer in that group and another was

248   included that otherwise would not have been and in the high performing group, one hospital was not included in the

249   Utsein group).

250   Discussion

251   In a large, international registry of patients treated with TTM after OHCA, profound differences in center-specific

252   rates of good functional outcomes were observed and persisted after adjustment for the major patient-specific factors

253   known to be associated with outcome. The four high-performing centers reported a greater use of temperature

254   management goal of 33 degrees, faster time to initiation of target temperature, higher rates early cardiac

255   catheterization and PCI (prior to awakening). There was also a higher utilization of continuous EEG and SSEP than

256   the low-performing centers. These post-resuscitation processes of care include treatments that could influence

257   outcome, such as TTM performance and PCI as well as diagnostic modalities (EEG, SSEP) that may be markers for

258   other elements of care such as a more nuanced approach to neurologic prognostication that incorporates multimodal

259   diagnostics[30, 31]. The center-specific differences in outcome were not fully explained by the treatment factors we

260   evaluated, suggesting others contribute, possibly including rewarming rate, hemodynamic management, oxygenation

261   and ventilation parameters, and glucose management, all of which have been shown to be independently associated

262   with outcome in prior studies[5, 32], but were not available in our data. Moreover, direct prognostication data

263   related to withdrawal of life sustaining therapy were also not available and may greatly impact outcomes[33-36]. We

264   did find that there was a difference in withdrawal of life sustaining therapy and ICU length of stay of three days or

265   less, suggesting that early prognostication practices differed between high and low-performing centers. Center

266   volume, although associated with outcome in the univariate model, was not associated with outcome in the

267   multivariable model and is inconsistent with other publications of high volume centers having more favorable

268   overall outcomes[9, 10]. The reason for this may be due to lack of statistical power to detect this effect. Our data

269   suggest there are center effects influencing OHCA outcomes. Reporting such severity-adjusted data may ultimately

270   help identify key features of high-quality post-resuscitation care, and define standards for assessing hospital

271   performance.

272

273   Our data agree with previous studies showing differences in cardiac arrest outcomes by center after various types of

274   adjustment. Merchant et al evaluated 135,896 in-hospital arrests from the American Heart Association's Get With

275   the Guidelines-Resuscitation Registry adjusted for 36 predictors of outcome and found adjusted in-hospital survival

276   rates ranged from 12.4 to 22.7% at different centers; although they included patients that did not achieve ROSC and

277   others treated without TTM[7]. Carr et al evaluated a multicenter clinical registry of ICU patients found in-hospital

278   mortality ranged from 46-68% between the 39 centers after adjusting for age, severity of illness and ventilation

279   status.[8] Our demonstration of variability in outcomes between centers after adjusting for the case mix is consistent

280   with these findings in a different population. Our methodology of risk adjustment decreased the likelihood of

281   overestimating center differences, which is a frequent error in random center effects modeling[29, 37].

282   The variations we observed in risk-standardized outcomes suggest that center-specific characteristics, either in terms

283   of resources, protocols, or practices may directly affect functional outcomes after cardiac arrest. These variations in

284   outcome represent an opportunity to identify which treatment factors, from the many identified as candidates, most

285   affect outcome. We identified several that appear to be important; time to initiation target temperature, early cardiac

286   catheterization and early PCI. Unfortunately, limitations in the data set precluded analysis of hemodynamic

287   management, ventilation and oxygenation parameters, glucose control, or how prognostication testing was

288   interpreted including withdrawal of life sustaining therapies policy. Other post-resuscitation treatments such as

289   sedation and shivering management[1], and seizure management [38] have also been shown to vary by center and

290   may contribute to outcomes. Our study did not have patient-level data for specific aspects of some of these

291   treatments including sedation and shivering data, seizure management, and how prognostic testing was interpreted.

292   Evaluating these factors in future studies may further improve our model. The differences in outcome associated

293 with use prognostication tests is likely more complex than the mere presence or absence of these tools; they could be

294 a marker for neurologist or neurointensivist involvement, and could relate to which patients receive that testing and

295 how the data are used to guide care, such as the early withdrawal of life support. Similar challenges have been

296 identified in other multicenter practice studies in other disease states[39], where an in-depth communication and

297 quality improvement effort was initiated with an improvement in outcomes[39]. This could be used as a platform for

298 process-improvement in centers that provide post-resuscitation care.

299 *Study Strengths and Limitations*

300 The strengths of this study include the benefits of a large, international dataset, which allows comparisons between

301 centers. We also used a method of risk adjustment that captures and corrects for differences in center size as

302 recommended by Centers for Medicare and Medicaid Services[29]. The INTCAR registry also allowed us to

303 evaluate some in-hospital factors to help understand some of the clinical differences between high and low

304 performing centers.

305 This study should be interpreted within the context of several limitations. Although data dictionaries were developed

306 to reduce variability in data entry and the registry guidelines were to enroll consecutive patients, sites were

307 responsible for internally monitoring the quality of their data entry. We also found that patients with nonshockable

308 rhythm were more likely to be unwitnessed. We believe this explains why there are fewer missing data among

309 patients with shockable rhythm. This did not appear to cluster at any particular hospital. Analysis after multiple

310 imputation showed similar odds ratios, with the exception of age, which was significant in nonimputed data and

311 nonsignificant in the imputed dataset. Limiting our analysis to data points that were concordant between the 1.0 and

312 2.0 data restricted our analysis and there were some variables that were not available in both datasets that may have

313 been useful, including etiology of arrest. The ability to further understand differences in care between high and low

314 performing centers would benefit from in-depth interviews and a review of full protocols and adherence to those

315 protocols to identify themes that may explain the variability in outcomes. Also, because centers participated in the

316 Registry at different time points, we were not able to evaluate patient volume, which has been associated with

317 improved outcomes[10, 11, 30]. Lastly, hospital discharge CPC was the outcome of interest rather than six month

318 CPC. Since longer-term outcome is influenced by other factors including post-discharge services, insurance status,

319 and other comorbidities, we felt that restricting the outcome to hospital discharge was the most appropriate for

320 addressing our research question.

321

322 This is the first study of its kind that introduces an accessible risk-adjustment model for comparing center

323 performance based on patient-level data for patients admitted with OHCA. Outcome differences for these patients

324 are not solely explained by differences in patient case mix, but also represent variations in patient care, which are

325 often unmeasured. The next steps of comparing processes across centers would be to attempt to uncover root causes

326 of systematic differences among centers; including sedation, shivering management, metabolic management,

327 applications prognostic tests, hemodynamic and ventilator targets, and seizure management. Nonetheless, it is of

328 interest that in an era where some are now questioning the utility of post cardiac arrest use of therapeutic

329 hypothermia and early coronary angiography, these results from a large post arrest car registry affirm their value in

330 high performing centers[40].

331

332 Conclusions

333 Considerable variability persists between centers in functional outcome among patients after OHCA at hospital

334 discharge despite adjustment for baseline risk. High performing centers more frequently have a faster time to target

335 temperature, provide cardiac catheterization and PCI prior to awakening, are more likely to utilize continuous EEG

336 and SSEP compared to low performing centers, but these differences only partially explain the differences in

337 outcomes noted. This model provides an opportunity to explore difference in care delivery and potentially improve

338 processes of care. Additional work is needed to establish normative standards for good outcomes after resuscitation

339 from out-of-hospital cardiac arrest based on risk adjustment, and to fairly assess hospital performance and

340 investigate the specific features of post-resuscitation care that directly influence patient outcomes.

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535   **Figure legends:**
536   Figure 1: Good outcome at hospital discharge by center after risk adjustment.
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538   Figure 2: Good outcome at follow-up by center after risk adjustment.
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581 **Tables:**
582

Patient Characteristics	
Number of patients	3855
Age mean (sd)	61.3 (15.4)
Female n (%)	1207 (31.3)
Witnessed n(%)	3061 (79.4)
European center n(%)	1520 (39.4)
Shockable Rhythm n(%)	2040 (52.9)
Medical diagnosis (median [IQR])	2 [0, 3]
Bystander CPR n(%)	2546 (66.0)
Time to ROSC (mean (sd))	26.2 (18.0)
Defibrillation n(%)	2472 (64.1)
Hospital CPC 1-2 n(%)	1,325 (34.4)

583 Table1: Patient characteristics
584 CPR = cardiopulmonary resuscitation; CPC = cerebral performance category; ROSC = return of
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Variable	Univariate OR (CI)	Multivariate OR (CI)
Age*	1.32 (1.27-1.38)	0.71 (0.67-0.76)
Female sex	1.91 (1.64-2.22)	0.72 (0.60-0.89)
Time to ROSC	0.95 (0.94-0.94	0.95 (0.94-0.95)
Medical Comorbidities**	0.73 (0.70-0.77)	0.83 (0.78-0.88)
Rhythm (shockable)	6.85 (5.85-8.06)	3.06 (2.79-4.66)
Bystander CPR	1.89 (1.62-2.19)	1.44 (1.20-1.74)
Witnessed	2.59 (2.14-3.15)	1.96 (1.55- 2.48)
Defibrillation	5.62 (4.73-6.71)	1.95 (1.47-2.60)

614   Table 2: Full univariate and multivariate model for outcome of dichotomized hospital discharge
615   CPC
616   Intercept: -3.06
617   *age by decade
618   **see supplement for individual medical comorbidities components
619   CPR = cardiopulmonary resuscitation; ROSC = return of spontaneous circulation
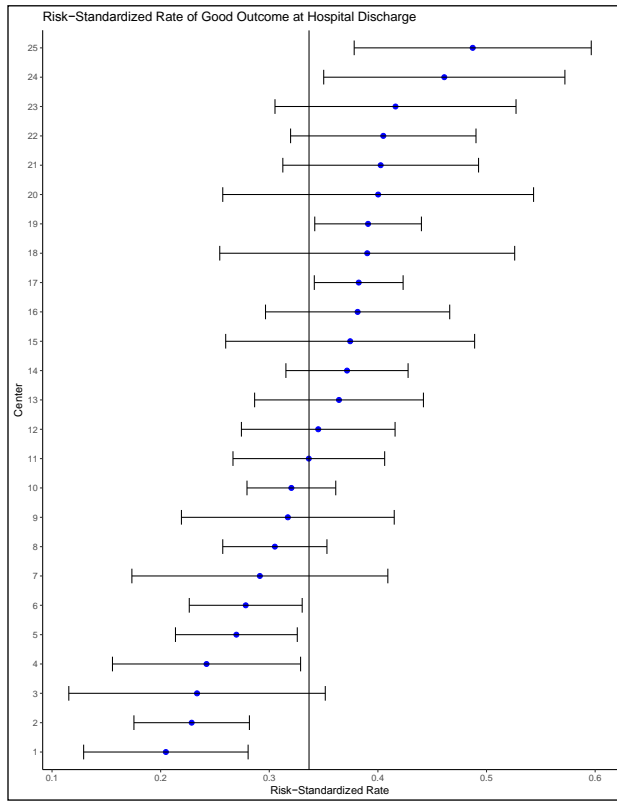620
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Characteristics	Low performing centers (n=1,311)	High performing centers (n=873)	p-value
Time to start of target temperature (mean, SD)	176 (141)	80 (80)	<0.001
Target temperature 33	1018 (83)	791 (91)	<0.001
Target temperature 36	157(13)	61 (7)	0.002
No TTM provided	49 (4)	20 (2.3)	0.08
Cardiac Catheterization unconscious- all patients (n, %)	411 (32)	451 (53)	<0.001
PCI unconscious- all patients (n, %)	201 (20)	246 (33)	<0.001
CABG unconscious- all patients (n, %)	5 (0.4)	3 (0.3)	
Cardiac Catheterization unconscious- all STEMI patients (n, %)	178 (15)	205 (24)	<0.001
Cardiac Catheterization unconscious- all patients with shockable rhythm (n, %)	303 (57)	347 (72)	<0.001
Cardiac Catheterization- all patients with shockable rhythm(n, %)	361 (68)	400 (83)	<0.001
PCI- all patients with shockable rhythm (n, %)	274 (51)	301 (62)	<0.001
Thrombolysis (n, %)	79 (7)	24 (3)	<0.001
Intra-aortic balloon pump (n, %)	152 (13)	103 (12)	0.423
Pneumonia diagnosis (n, %)	417 (36)	322 (37)	0.662
Fever in first 72 hours (n, %)	337 (34)	290 (36)	0.395
Volume (median, IQR)	42 (22, 44)	46 (45, 46)	<0.001
In patients with poor outcome; use of diagnostic tests			
	1005	485	
EEG in poor outcome (n, %)	614 (61)	283 (58)	0.338
Continuous EEG (n, %)	351 (35)	196 (40)	0.045
MRI (n, %)	179 (18)	58 (12)	0.005
SSEP (n, %)	64 (6)	89 (18)	<0.001
CT (n, %)	588 (59)	274 (56)	0.496

Table 3: Characteristics of 4 high performing centers and 5 low performing centers
CABG = cardiopulmonary resuscitation; CPR = cardiopulmonary resuscitation; CPC = cerebral
performance category; CT = computed tomography; EEG = electroencephalography; ICU =
intensive care unit; MRI = magnetic resonance imaging; ROSC = return of spontaneous
circulation; SSEP = somatosensory evoked potentials

Figure 1

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Figure 2
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