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1 Mortality from Ruptured Abdominal Aortic Aneurysms: Clinical Lessons from a
2 Comparison of Outcomes in England and the USA.

3

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21

22

23

24 **ABSTRACT**

25

26 **Background**

27 The fate of patients with ruptured abdominal aortic aneurysm (rAAA) has been shown
28 to vary by country. More detailed study to compare practice might reveal the source
29 of variation, and allow the formulation of pathways to improve care. This study
30 compared in-hospital mortality for rAAA in England and the USA.

31 **Methods**

32 The English Hospital Episode Statistics and the USA Nationwide Inpatient Sample
33 were compared for patients hospitalized with rAAA from 2005 to 2010. In-hospital
34 mortality and the rate of non-corrective (conservative/palliative) treatment were
35 analyzed by binary logistic regression for each healthcare system, after adjustment for
36 age, gender, year, and Charlson co-morbidity index.

37

38 **Results**

39 The study included 11,986 patients with rAAA in England, and 23,838 rAAA in the
40 USA. In-hospital mortality was greater in England (65.90% vs 53.05%, $p < 0.001$).
41 Intervention (open or endovascular repair) was offered to a greater proportion of cases
42 (80.43% vs 58.45%, $p < 0.001$) and endovascular repair (rEVAR) was more common
43 (20.87% vs 8.54%, $p < 0.001$) in the USA. These observations persisted in age/gender-
44 matched comparison. In both countries, lower mortality was associated with rEVAR,
45 greater hospital caseload (volume) for rAAA, hospital bed capacity and teaching
46 status, and admission on a weekday.

47 **Conclusion**

48

49 In-hospital survival from rAAA, intervention rates and the uptake of rEVAR are
50 lower in England than the USA. In both England and the USA, the lowest mortality
51 for rAAA was seen in teaching hospitals with larger bed-capacity performing a
52 greater proportion of cases with endovascular repair. These common factors suggest
53 strategies for improving outcomes for patients with rAAA.

54 **INTRODUCTION**

55

56 The rupture of an abdominal aortic aneurysm (rAAA) is frequently fatal and accounts
57 for the death of at least 45 individuals per 100,000 population.¹ Surgical intervention
58 remains associated with high mortality despite evidence of improvement in published
59 outcomes over recent decades.² In both the USA and England, there is evidence of
60 inter-hospital variation in the mortality of patients admitted with rAAA. The fate of
61 patients with AAA has also been shown to vary between countries, with differing
62 outcomes published for a range of healthcare systems including the USA, UK,
63 Western Europe and Australia.³⁻⁵

64

65 Modifiable technical, organisational or hospital-related factors play an important role
66 in patient care, and merit further study in order to optimise service delivery and
67 improve patient outcomes. A detailed study to compare international outcomes for
68 rAAA would place data from an individual healthcare system in a broader context,
69 and might allow the identification of factors that influence survival or the formulation
70 of pathways to improve care.

71

72 The present study reported the outcomes of patients with rAAA in England and the
73 USA, with comparison of in-hospital mortality, the proportion of patients managed by
74 non-corrective treatment (i.e. conservative or palliative care), and the availability of
75 endovascular surgery.

76

77

78 **METHODS**

79

80 Demographic and in-hospital outcome data were extracted from Hospital Episode
81 Statistics (HES) and the Nationwide Inpatient Sample (NIS) for all patients diagnosed
82 with rAAA between 1 January 2005 and 31 December 2010. The HES are the
83 administrative data set for the English National Health Service (NHS) and contain
84 information regarding every admission of a patient to hospital. The Nationwide
85 Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP) is
86 an anonymised, stratified sample of 20% of all discharges from USA hospitals, and
87 represents the largest all-payer database of hospital admissions for USA healthcare.

88

89 The inclusion criteria comprised patients with a diagnosed rAAA, defined by
90 International Classification of Diseases-10 (ICD-10) codes in HES and ICD9-CM
91 codes in NIS data, as listed in the online appendix. Endovascular (rEVAR) and Open
92 (OR) rAAA repairs were identified according to previously published methodology
93 for the HES, and as listed in the online appendix for the NIS.^{4,6-8} The primary
94 outcome measures were in-hospital mortality, operative mortality and the decision to
95 follow non-corrective (conservative/palliative) treatment for rAAA. Non-corrective
96 treatment was defined by the patient having a diagnostic code for rAAA but no
97 procedural code for surgical or endovascular rAAA repair. Secondary outcome
98 measures included the proportion of operated cases managed by rEVAR, length of
99 stay, discharge destination, and the proportion of cases managed in teaching hospitals
100 or hospitals of varying bed-capacity.

101

102 Patient-level and hospital-level factors were extracted to enable comparable risk-
103 adjustment in both HES and NIS data. These included age, gender, hospital and, year
104 of admission. Pre-existing co-morbidity was defined separately for the USA and
105 England with techniques validated independently for each country: using the Charlson
106 Index for the NIS⁹ and the Royal College of Surgeon's modified Charlson Index for
107 HES.¹⁰ Due to systematic differences in coding policies between the USA and
108 England, risk adjustment for comorbidity was only used for within-country analysis
109 rather than for comparative analysis between countries. Hospital factors included bed
110 capacity, teaching status and, institutional annual volume (caseload) for rAAA.
111 Hospital teaching status and bed capacity were defined according to standard NIS
112 documentation, and classified for English hospitals from publicly-available data
113 according to previously defined methodology.^{11,12} Institutional volume (caseload) for
114 rAAA was represented using quintiles according to previously defined
115 methodology.¹²

116

117 Statistical analysis

118 All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC, USA)
119 and STATA version 12.0 (Statacorp LP, Statacorp, Texas, USA).

120

121 Primary and secondary outcomes were modelled separately for HES and NIS data,
122 using binary logistic regression with risk-adjustment for age, gender, social
123 deprivation and co-morbidity index. Stepwise selection procedures were used with
124 comparison of models by Akaike's Information Criterion (AIC) to ascertain whether
125 individual covariates improved goodness-of-fit for prediction of in-hospital mortality
126 and non-corrective treatment. Covariates considered for modelling included age,

127 gender, social deprivation, comorbidity index, institutional procedural volume
128 (caseload), institutional bed capacity and teaching status, geographical region and
129 year of surgery, inter-hospital transfer status, and admission on a weekend versus a
130 weekday. Inclusion in the model required a significance level of $\alpha = 0.1$, and
131 significant results were reported at $\alpha=0.05$.

132

133 Age and gender-matched analyses were constructed to compare English and USA
134 outcomes for in-hospital mortality and the decision to offer non-corrective treatment.
135 HES and NIS datasets were linked using common variables defined above, and strata
136 were created after matching patients for gender and 5-year age groups. Person-level
137 matching was performed within each strata, allowing patients of equivalent gender
138 and 5-year age group to be paired. Matched person-level comparisons of in-hospital
139 mortality and the rate of non-corrective (conservative/palliative) treatment were
140 performed between English and USA patients using McNemar's test for statistical
141 significance.

142

143 **Funding and Authorship**

144 All authors had access to the study data throughout. Funding from the Circulation
145 Foundation and the National Institute for Health Research (NIHR) supported the
146 academic salary of authors AK and PJH but the funding bodies had no direct input
147 into the content or interpretation of the present study.

148

149

150

151 **RESULTS**

152

153 11,799 patients in England and 23,838 patients in the USA were admitted to hospital
154 with a rAAA during the study period. In England the mean (sd) age was 78.2 (8.0)
155 years and 73.7% were male. In the USA, the mean (sd) age was 76.6 (9.6) years and
156 71.4% of patients were male. Full demographic details of patient characteristics are
157 provided in the Supplementary Appendix.

158

159 **In Hospital Mortality, Non-Corrective Treatment and Use of Endovascular**

160 **Repair**

161

162 In-hospital mortality was greater in England than the USA (65.90% vs 53.05%,
163 $p < 0.001$) [Table 1]. Intervention (rEVAR or open surgery) was offered to a greater
164 proportion of cases in the USA (80.43% vs 58.56%, $p < 0.001$) and endovascular
165 repair was more common in the USA (20.87% vs 8.54%, $p < 0.001$). Amongst patients
166 who underwent intervention, mortality was similar in both countries (41.77% vs
167 41.65%, $p = 0.876$). Mortality from endovascular repair was consistently lower than
168 for open surgery, but comparative mortality following rEVAR was lower in the USA
169 than England (26.84% vs 31.58%, $p = 0.018$). A comparison of matched strata
170 between England and the USA demonstrated that in patients of equivalent age and
171 gender, overall in-hospital mortality and the rate of non-corrective treatment were
172 significantly lower in the USA than England ($p < 0.001$, Figure 1 and Figure 2).

173

174 **Length of Stay, Discharge Destination and Teaching Hospital Status**

175

176 The median length of stay of survivors of rAAA was longer in England (10·6 vs 16
177 days, $p<0\cdot001$). English patients were more commonly discharged to their usual place
178 of residence (79·99% vs 33·70%, $p<0\cdot001$) whereas USA patients were more
179 commonly discharged to an alternative healthcare provider (66·14% vs 19·14%,
180 $p<0\cdot001$), including 24% discharged to a skilled nursing facility [Table 2]. The
181 discrepancy in discharge destinations provides important context for the present
182 study's comparison of in-hospital mortality. Although a similar proportion of
183 hospitals were described as teaching institutions in both countries (15·14% vs
184 17·35%, $p=0\cdot495$), a greater proportion of rAAA in the USA were treated at teaching
185 institutions (51·53% vs 29·29%, $p<0\cdot001$, Table 1).

186

187 **Predictors of In Hospital Mortality and Non-Corrective Treatment in England**
188 **and the USA**

189 Mortality was lower at teaching institutions than non-teaching institutions in both
190 countries (England - 56·04% vs 69·99% and USA - 48·43% vs 58·05%, $p<0\cdot001$)
191 [Table 2]. The non-corrective treatment rate was also lower in teaching institutions in
192 both countries (England - 31·32% vs 45·63% and USA - 14·93% vs 24·62% ,
193 $p<0\cdot001$). EVAR was more prevalent in teaching institutions (England - 6·14% vs
194 13·12% and USA - 15·54% vs 25·35%, $p<0\cdot001$). In both countries, mortality and
195 non-corrective treatment rates were better in hospitals with the highest bed capacity
196 [Table 3], in patients who were transferred, and in patients treated on a weekday
197 rather than a weekend (see Supplementary Appendix).

198

199 After adjusting for age, gender, co-morbidity, year and hospital size/caseload;
200 predictors of mortality in England included admission on a weekend rather than a

201 weekday (OR 1.144, 95% CI 1.037-1.263, $p=0.007$), inter-hospital transfer rather
202 than treatment in the presenting hospital (OR 0.646, 95% CI 0.563-0.739, $p<0.001$),
203 and treatment outside a teaching institution (OR 1.462, 95% CI 1.310-1.631,
204 $p<0.001$) [see Supplementary Appendix]. In the USA, predictors of mortality
205 included admission on a weekend (OR 1.156, 95% CI 1.005-1.337, $p=0.043$) and
206 treatment outside a teaching institution (OR 1.272, 95% CI 1.037-1.560, $p=0.024$).
207 After risk adjustment in England, non-corrective treatment was more likely in patients
208 admitted over a weekend (OR 1.274, 95% CI 1.154-1.407, $p<0.001$) or treated at
209 non-teaching institutions (OR 1.459, 95% CI 1.301-1.636, $p<0.001$). Non-corrective
210 treatment was less likely after inter-hospital transfer in both England (OR 0.431, 95%
211 CI 0.367-0.507, $p<0.001$) and the USA (OR 0.637, 95% CI 0.431- 0.943, $p=0.024$).

212

213

214

215 **DISCUSSION**

216

217 The main finding of this study was that the in-hospital mortality of patients with
218 rAAA was considerably lower in the USA than in England. This was principally
219 because USA hospitals were less likely to manage rAAA by non-corrective treatment
220 and offered aneurysm repair to a significantly greater proportion of patients. Although
221 operative mortality rates were similar, patients in the USA were more than twice as
222 likely to be offered rEVAR and were more often managed in a teaching hospital,
223 compared to England.

224

225 The proportion of patients offered intervention (rEVAR or open repair) in the USA
226 presented a stark difference to England, and provides important context for improving
227 English practice.^{13,14} Previous studies of Medicare beneficiaries in the USA have
228 reported that 68% of patients with rAAA were offered intervention.^{15,16} Although this
229 was lower than the estimate of 80% from the present study and other NIS reports, the
230 proportion offered intervention in the USA has been consistently reported to be
231 greater than in England.³ Post-operative mortality was similar in both countries,
232 suggesting that overall survival from rAAA in England would be improved by
233 offering intervention to a greater proportion of patients, to lower the rate of non-
234 corrective treatment. Published clinical data support this theory, and have
235 demonstrated that an aggressive management strategy with a lower rate of non-
236 corrective treatment results in lower overall mortality from rAAA.

237

238 The data did not permit reporting of 30-day mortality and it should be noted that a
239 greater proportion of patients were discharged to a healthcare provider in the USA

240 compared to England, where most patients were discharged home. The proportion of
241 patients that died after discharge from the primary facility is unknown. Comparisons
242 of in-hospital mortality should therefore be interpreted with a degree of caution to
243 acknowledge the risk of confounding by different discharge policies. Further research
244 should also investigate international disparities in 90-day mortality rates, which may
245 mitigate against differences in critical care provision. However, it remains unlikely
246 that the 13% absolute mortality difference could be entirely explained by deaths in
247 secondary care given the stark difference in non-corrective treatment rates.

248

249 Previous studies have shown that the outcome of rAAA repair is partly determined by
250 patient-level factors including age, gender and co-morbidity.¹⁷⁻²¹ The present study
251 adds new insights by demonstrating that common hospital-level factors influenced
252 outcomes in both healthcare systems. In both countries, in-hospital mortality was
253 more likely in patients treated on a weekend rather than a weekday, or in patients
254 treated outside a “teaching” institution.

255

256 In both England and the USA, the best outcomes were obtained in hospitals with the
257 highest bed capacity, the greatest annual caseload (volume) of rAAA, and in hospitals
258 in which a larger proportion of rAAA were managed by rEVAR. These findings add
259 to previous evidence that a volume-outcome relationship exists for operative mortality
260 after rAAA in both England and America.^{22,23} Hospital bed size, teaching status,
261 admission on a weekday and rAAA caseload might all be regarded as inter-related
262 surrogate markers for the immediacy with which each rAAA patient had access to the
263 full range of technology and care by a specialist multidisciplinary team.

264

265 Previous studies have demonstrated higher mortality associated with weekend
266 admission for a range of emergency conditions in the English National Health
267 Service.^{24,25} The international data presented here reinforce these concerns and
268 illustrate that the challenge of providing high-quality out-of-hours care is widespread.
269 The results from the present study suggest that service configuration should focus on
270 ensuring that patients with a ruptured AAA are treated in a teaching hospital with a
271 high aortic workload, offering both conventional and endovascular repair.

272

273 The present study demonstrated superior outcomes in those treated by endovascular as
274 compared to open repair in both England and the USA, and was consistent with other
275 large studies documenting the outcomes of clinical practice. In the elective setting,
276 randomised trials have consistently demonstrated lower operative mortality after
277 EVAR for non-ruptured AAA, but this finding has not been replicated by a
278 randomised trial for rAAA patients. Nonetheless, the evidence from national
279 outcomes research remains compellingly in favour of rEVAR, and for many experts
280 the role for a randomised study of rEVAR versus open repair remains controversial.
281 Due to the design of the study, the endovascular outcomes could not be adjusted for
282 aortic morphology or haemodynamic status. There was a significant difference in the
283 utilisation of endovascular repair with a threefold greater uptake of rEVAR in the
284 USA. It has been shown that approximately 50% of patients with rAAA are
285 morphologically suitable for rEVAR, yet the adoption of rEVAR in both countries
286 remained short of this benchmark²⁸.

287

288 The limitations of this study relate to the observational nature of the administrative
289 datasets that were analysed. However there was clear evidence that the outcomes of

290 rAAA in England are worse than in the USA. In-hospital mortality is higher in
291 England and this appears attributable to the lower proportion offered intervention. The
292 uptake of rEVAR is low in England. Common hospital-level factors were associated
293 with mortality from rAAA in both countries and should inform improvements to
294 service configuration.

295

296 **Conflicts of interest:**

297 None

298

299

300

301 **Authors' contributions:**

302 Alan Karthikesalingam: conception and design, analysis and interpretation, drafting
303 and revision of manuscript, final approval of version for publication.

304 Peter J Holt: design, interpretation, drafting and revision of manuscript, final approval
305 of version for publication.

306 Alberto Vidal-Diez: design, analysis, interpretation, revision of manuscript, final
307 approval of version for publication.

308 Baris A Ozdemir: design, interpretation, and revision of manuscript, final approval of
309 version for publication.

310 Jan D Poloniecki: design, analysis, revision of manuscript, final approval of version
311 for publication.

312 Robert J Hinchliffe: design, interpretation, revision of manuscript, final approval of
313 version for publication.

314 Matthew M Thompson: conception and design, analysis and interpretation, drafting
315 and revision of manuscript, final approval of version for publication, guarantor of
316 work.

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408 Table 1: Primary Outcomes after rAAA in England and USA.

409

	England	USA (95% confidence interval)	P-value
Number of Patients	11799	23838	
Operated Patients (n, %)	6897 (58.45%)	19174 (80.43%) (78.99% - 81.88%)	< 0.001
In-hospital Mortality (%)	65.90%	53.05% (51.26% - 54.85%)	< 0.001
Post-operative Mortality (%)	41.77%	41.65% (39.93% - 43.39%)	0.88
rEVAR (%)	8.54%	20.87% (18.59% - 23.16%)	< 0.001
Open repair mortality (%)	42.72%	45.57% (43.6% - 47.54%)	< 0.001
rEVAR mortality (%)	31.58%	26.84%	0.018
Length of Stay Median (IQR)	Overall 4(13) Dead in hospital 1(4) Survivors 16(18)	Overall 4.6 (11.9) Dead in hospital 0.44 (2.3) Survivors 10.59 (12.45)	
% Discharged Home	79.99%	33.70% (31.42%-35.98%)	<0.001
% Discharged to other healthcare provider	19.17%	66.14% (63.87%-68.42%)	<0.001
% Teaching Hospitals in analysis	15.14%	17.35% (16.68% - 18.01%)	0.50
% rAAA Treated in Teaching Hospital	29.29%	51.53% (48.32%-54.76%)	<0.001

410

411 *95% confidence intervals are provided for USA data, to reflect the precision of the

412 sample-derived national estimates. Data for England are not derived from a sample

413 and therefore no confidence intervals are required.

414

415

416

417 Table 2: Comparison of outcomes in teaching and non-teaching hospitals in England

418 and USA

419

	Teaching hospital England	Non-teaching Hospital England	p-value	Teaching hospital USA	Non-teaching hospital USA	p-value
All mortality (operated and non-operated)	56.04%	69.99%	<0.001	48.43% (45.89% - 50.98%)	58.05% (55.74% - 60.37%)	<0.001
Operative mortality (operated cases only)	35.99%	44.8%	<0.001	39.43% (37.1% - 41.77%)	44.35% (41.88% - 46.83%)	<0.001
% of Operated cases done by EVAR	13.12%	6.14%	<0.001	25.35% (21.92% - 28.78%)	15.54% (12.96% - 18.12%)	<0.001
Non-corrective treatment rate (% of all cases that are not operated)	31.32%	45.63%	<0.001	14.93% (13.07% - 16.79%)	24.62% (22.55% - 26.73%)	<0.001
Mortality EVAR	28.62%	34.89%	0.1104	25.19% (21.53% - 28.84%)	30.54% (24.48% - 36.6%)	<0.001
Mortality Open	37.11%	45.45%	<0.001	44.27% (41.42% - 47.12%)	46.89% (44.22% - 49.56%)	0.001

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422 Table 3: Comparison of outcomes in low-volume, middle-volume and high-volume
 423 hospitals in England and USA.

	Low-bed capacity England (% of total)	Middle bed capacity England	High-bed capacity england	Low bed capacity USA	Middle bed capacity USA	High bed capacity USA
All mortality (operated and non-operated)	82.56%	68.64%	61.89%	75.86% (73.31 - 78.42)	51.33% (48.38 - 54.27)	43.82% (41.53 - 46.1)
Operative mortality (operated cases only)	46.32%	44.65%	40.18%	50.64% (46.25%- 55.03%)	44% (40.96%- 47.06%)	38.32% (36.12%- 40.53%)
% of Operated cases done by EVAR	9.21%	7.03%	9.12%	16.27%	17.43%	23.73%
Non-corrective treatment rate (% of all cases that are not operated)	67.52%	43.34%	36.29%	51.29% (48.49%- 54.09%)	13.07% (11.15%- 15%)	8.91% (7.67%- 10.14%)
Mortality EVAR	25.71%	36.76%	30.38%	34.45% (24.43%- 44.48%)	29.77% (23.09%- 36.47%)	24.49% (20.7%- 28.28%)
Mortality Open	48.41%	45.25%	41.16%	53.79% (49.06%- 58.51%)	47.01% (43.69%- 50.34%)	42.63% (39.97%- 45.29%)

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428 Figure 1: In-hospital Mortality for rAAA after person-level matching for gender and
429 5-year age grouping. $p < 0.0001$ for paired comparison of England versus America;
430 McNemar's test.

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433 Figure 2: Non-corrective treatment for rAAA after person-level matching for gender
434 and 5-year age grouping. $p < 0.0001$ for within-strata comparison of England versus
435 America; McNemar's test.

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439 Supplementary Appendix 1: Patient Characteristics in England and USA
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Variable	England	USA	P-value
Mean Age (SD)	78.19 (8.01)	76.58 (9.58)	<0.001
% Male	73.68%	71.41% (70% - 72.81%)	<0.001
Myocardial Infarction	8.8%	14.81% (13.76% - 15.86%)	<0.001
Congestive Heart Failure	15.07%	15.09% (14.05% - 16.13%)	0.97
Cerebrovascular disease	11.7%	4.33% (3.74% - 4.9%)	<0.001
Dementia	5.27%	2.13% (1.72% - 2.55%)	<0.001
Chronic Pulmonary Disease	23.81%	32.16% (30.76% - 33.57%)	<0.001
Connective Tissue Disease	3.09%	1.4% (1.08% - 1.72%)	<0.001
Liver Disease	2.26%	5.32% (4.66% - 5.97%)	<0.001
Diabetes	10.53%	12.7% (11.73% - 13.66%)	<0.001
Paraplegia	2.55%	0.99% (0.72% - 1.26%)	<0.001
Renal disease	12.09%	15.06% (13.94% - 16.18%)	<0.001
Any Malignancy	9.29%	3.36% (2.85% - 3.86%)	<0.001
Metastatic Carcinoma	1.28%	0.96% (0.69% - 1.23%)	0.007

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444 Supplementary Appendix 2: Comparison of outcomes in patients who are transferred
 445 in England and USA

	Transferred Patients England	Non-transferred patients England	p-value	Transferred Patients USA	Non-transferred patients USA	p-value
All mortality (operated and non-operated)	51.96%	67.56%	<0.001	40.52% (35.66% - 45.37%)	52.58% (50.16% - 55%)	<0.001
Operative mortality (operated cases only)	37.75%	42.43%	0.006	34.42% (30.08% - 38.75%)	40.05% (37.57% - 42.54%)	<0.001
% of Operated cases done by EVAR	8.75%	7.24%	0.12	31.33% (25.44% - 37.22%)	26.01% (22.85% - 29.17%)	<0.001
Non-corrective treatment rate (% of all cases that are not operated)	22.83%	43.65%	<0.001	9.31% (6.1% - 12.51%)	20.98% (18.92% - 23.04%)	<0.001
Mortality EVAR	27.14%	32.18%	0.49	23.87% (17.02% - 30.74%)	23.68% (19.76% - 27.6%)	0.92
Mortality Open	38.57%	43.41%	0.007	39.23% (33.29% - 45.16%)	45.81% (42.86% - 48.75%)	<0.001

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453 Supplementary Appendix 3: Comparison of outcomes on weekends and weekdays in

454 England and USA

	Weekday England	Weekend England	p-value	Weekday USA	Weekend USA	p-value
All mortality (operated and non- operated)	65.27%	67.67%	0.005	52.51% (50.48%- 54.52%)	54.52% (51.72%- 57.31%)	0.006
Operative mortality (operated cases only)	41.87%	41.48%	0.98	40.86% (38.85%- 42.88%)	43.76% (40.8%- 46.7%)	<0.001
% of Operated cases done by EVAR	8.77%	7.85%	0.25	21.48% (19.06%- 23.9%)	19.29% (16.25%- 22.33%)	<0.001
Non- corrective treatment rate (% of all cases that are not operated)	40.26%	44.76%	<0.001	19.73% (18.15%- 21.31%)	19.13% (16.8%- 21.46%)	0.30
Mortality EVAR	31.87%	30.6%	0.83	24.8% (21.37%- 28.26%)	32.79% (26.23%- 39.36%)	<0.001
Mortality Open	42.83%	42.4%	0.77	45.26% (42.97%- 47.54%)	46.38% (42.95%- 49.8%)	0.22

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458 Supplementary Appendix 4: Logistic Regression Models of In-hospital Mortality in
 459 England and USA. Models risk-adjusted for Age, Gender and Co-morbidity Index.

Covariate	HES (England)		NIS (USA)	
	<i>OR (95% CI)</i>	<i>p-value</i>	<i>OR (95% CI)</i>	<i>p-value</i>
Weekend Admission	1.144 1.037- 1.263	0.007	1.156 1.005-1.337	0.043
Transfer**	0.646 0.563- 0.739	<0.001	0.839 0.662-1.064	0.15
Non-Teaching Institution	1.462 1.310- 1.631	<0.001	1.272 1.037-1.560	0.023
Institutional rAAA Volume	*	<0.001	*	<0.001
Region	*	<0.001	*	0.099
Year	*	<0.001	*	<0.001
Hospital size (Number of beds)	*	0.46	*	0.10
Rural location	Not available	-	0.987 0.739-1.318	0.93
Hospital control	Only public hospitals	-	*	0.013

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461 *Odds ratios for categorical comparisons.

462 ** NIS data only available from 2008 onwards.

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465 Supplementary Appendix 5: Logistic Regression Models of Non-Corrective

466 Treatment (Conservative or Palliative Management) for rAAA in England and USA.

467 Models risk-adjusted for Age, Gender and Co-morbidity.

Covariate	HES (England)		NIS (USA)	
	<i>OR (95% CI)</i>	<i>p-value</i>	<i>OR (95% CI)</i>	<i>p-value</i>
Weekend Admission	1.274 1.154- 1.407	<0.001	1.005 0.818-1.235	0.96
Transfer	0.431 0.367- 0.507	<0.001	0.637 (0.431- 0.943)	0.024
Non-Teaching Institution	1.459 1.301- 1.636	<0.001	1.029 0.704-1.504	0.74
Institutional rAAA Volume	*	<0.001	*	<0.001
Region	*	<0.001	*	0.001
Year	*	<0.001	*	0.36
Hospital size (number of beds)	*	0.73	*	0.10
Rural location	Not available		1.339 0.961-1.867	0.085

Hospital control	Only public hospitals		*	0.75
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469 Supplementary Appendix 6: Logistic Regression modelling of Operative Mortality in

470 England and USA. Models risk-adjusted for Age, Gender and Co-morbidity.

Covariate	HES (England)		NIS (USA)	
	<i>OR (95% CI)</i>	<i>p-value</i>	<i>OR (95% CI)</i>	<i>p-value</i>
Open repair	1.773 1.459-2.154	< 0.001	2.299 1.908-2.769	<0.001
Weekend Admission	1.004 0.895-1.127	0.94	1.180 1.012-1.375	0.035
Transfer	0.866 0.746-1.006	0.060	1.101 0.852-1.421	0.46
Non-Teaching Institution	1.246 1.096-1.416	<0.001	1.235 0.987-1.544	0.06
Institutional rAAA Volume	*	0.037	*	<0.001
Region	*	0.004	*	0.007
Year	*	0.001	*	0.002
Hospital size (number of beds)	*	0.65	*	0.06
Rural location	Not available		0.857 0.62-1.184	0.35
Hospital control	Only public hospitals		*	0.06

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