

Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

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Appendix To: The Threshold for Aortic Aneurysm Repair in England and the United States

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Supplementary Methods

Data Sources

Hospital Episode Statistics (HES) are the administrative dataset for the English National Health Service (NHS) and contain information regarding every admission of a patient to hospital.

The Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ) is an anonymised, stratified sample of 20% of all discharges from USA hospitals used to generate nationally-representative estimates of hospital healthcare, and represents the largest all-payer database of hospital admissions for USA healthcare.

Medicare is the federal health insurance program for people who are 65 or older, certain younger people with disabilities, and people with End-Stage Renal Disease (permanent kidney failure requiring dialysis or a transplant). For the present study, only beneficiaries with coverage from both “Medicare Part A” and “Medicare Part B” were included. Medicare Part A (Hospital Insurance) covers inpatient hospital stays, care in a skilled nursing facility, hospice care, and some home health care. Part B (Medical Insurance) covers certain doctors' services, outpatient care, medical supplies, and preventive services.

The National Vascular Registry (NVR) is a mandatory online registry for all aneurysm repairs performed in the UK National Health Service (NHS) commissioned by the Healthcare Quality Improvement Program (HQIP) agency, and provides a representative description of aneurysm repair performed in England, with reliable data concordance to HES (the NVR is audited annually against administrative hospital statistics, audited internally for data accuracy and completeness before publication, and recorded infrarenal aneurysm repair with 84% case ascertainment for 2014).

The American College of Surgeons National Surgical Quality Improvement Programme (NSQIP) is a national clinical registry of self-selected hospitals in the USA with an interest in quality improvement and improved risk adjustment. From the general NSQIP, a more clinically detailed targeted vascular module was created in 2011 to collect additional anatomic and patient characteristics, including maximum aneurysm diameter, for aortic aneurysm cases at each participating hospital, and utilised for this study. All data in both NSQIP models was collected by trained clinical nurse reviewers.

Public Health England is responsible for the nationwide NHS National Abdominal Aortic Aneurysm Screening Programme (NAAASP), which invites all men in England for ultrasound screening to detect an abdominal aortic aneurysm in their 65th year. Men over 65 may self-refer into the programme. The implementation of NAAASP commenced in 2009, and reached national coverage during 4 years through an expanding number of local programmes based on populations above 800,000. National coverage was fully implemented by 2013.

The World Health Organisation (WHO) Global Infobase is a data warehouse that collects, stores and displays information on chronic diseases and their risk factors for all WHO member states, including England and USA. The data are derived at country level from Ministry of Health national estimates, national health surveys, demographic and health surveys, household surveys from other United Nations organizations, WHO-sponsored survey instruments, and external research. It was accessed through an online dissemination tool free at the point of use:
<https://apps.who.int/infobase/Index.aspx>

The International Mortality and Smoking Statistics database presents estimates for international smoking statistics for standardized age groups averaged by sex, 5-year period, and 5-year age group, with survey-derived data including England and the USA.

Case Ascertainment (Medicare)

Patients were included in the study if they had been continuously enrolled in Medicare Parts A and B for at least 2 years before aneurysm repair. Patients with a discharge diagnosis of abdominal aortic aneurysm without rupture (code 441.4 in the *International Classification of Diseases, 9th Revision, Clinical Modification* [ICD-9-CM]) who also had a procedural code for open surgical repair (38.44 [resection of abdominal aorta with replacement] or 39.25 [aortoiliac–femoral bypass]) or for endovascular repair (39.71 [endovascular implantation of graft]) were included. We excluded all patients with diagnostic codes for ruptured abdominal aortic aneurysm (441.3), thoracic aneurysm (441.1 or 441.2), thoracoabdominal aortic aneurysm (441.6 or 441.7), or aortic dissection (441.00–441.03). We also excluded those with procedural codes for repair of the thoracic aorta (38.35, 38.45, or 39.73) or visceral or renal bypass (38.46, 39.24, or 39.26). Data on beneficiaries who enrolled in Medicare Advantage during the follow-up period were censored from the analyses of complications and reinterventions because subsequent claims data were not available.

To improve coding accuracy for repair type, we compared the claims made by the physicians with the corresponding hospitalization codes. In cases in which the codes used by the hospital conflicted with those used by the physician, we assigned procedures on the basis of the physicians' claims.

Case Ascertainment (Hospital Episode Statistics)

Non-ruptured aneurysm repair was defined by the combination of a diagnostic ICD-10 code listed in Table S1 with any of the listed procedural OPCS-4 codes. Ruptured aneurysm hospitalisation was defined by an ICD-10 diagnostic code for I713 or I718 as listed in Table S1.

Case Ascertainment (Nationwide Inpatient Sample)

Non-ruptured aneurysm repair was defined by the combination of a diagnostic ICD-9CM code listed in Table S1 with any of the listed ICD-9CM procedure codes. Ruptured aneurysm hospitalisation was defined by an ICD-9CM diagnostic code 441.3 or 441.5 as listed in Table S1

Table S1: Coding lists used to define non-ruptured abdominal aortic aneurysm repair in HES, NIS and Medicare datasets

ICD-10 Diagnostic codes for HES:

I714: Abdominal aortic aneurysm, without mention of rupture

I719: Aortic aneurysm of unspecified site, without mention of rupture

OPCS-4 Procedural codes for HES:

L184, L185, L186, L188, L189 Emergency replacement of aneurysmal segment of infra-renal abdominal aorta

L194, L195, L196, L198, L199 Replacement of aneurysmal segment of infra-renal abdominal aorta

L231, L236, L238-239 Plastic repair of aorta

L254, L258, L259 Operations on aortic aneurysm NEC

L49 Replacement of aneurysmal iliac artery

L271 Endovascular insertion of stent graft for infra-renal abdominal aortic aneurysm

L275 Endovascular insertion of stent graft for aortic aneurysm of bifurcation NEC*

L276 Endovascular insertion of stent graft for aorto-uniiliac aneurysm

L278 Other specified transluminal insertion of stent graft for aneurysmal segment of aorta

L279 Unspecified transluminal insertion of stent graft for aneurysmal segment of aorta

L281 Endovascular stenting for infra-renal abdominal aortic aneurysm

L285 Endovascular stenting for aortic aneurysm of bifurcation NEC*

L286 Endovascular stenting for aorto-uniiliac aneurysm

L289 Unspecified transluminal operations on aneurysmal segment of aorta

Any elective or emergency open aneurysm code in conjunction with (Y022 [other specified other endovascular placement of stent] and Z346 Z347 Z348 Z349

[abdominal aorta, infra-renal abdominal aorta, aorta NEC*]), (O203 O204 O205

O208 O209 [endovascular placement of one or more stent grafts] and Y528 Y53

Y76.9 Y78 [other specified approach to organ through other opening, approach to organ under radiological control, unspecified minimal access to other body cavity,

arteriotomy approach to organ using radiological guidance]), (L281 L285 L286 L289) or (L761 L762 L765 L768)

ICD-9CM Diagnostic codes for NIS:

441.4 Abdominal aneurysm without mention of rupture

441.9 Aortic aneurysm of unspecified site without mention of rupture

ICD-9CM Procedure codes for NIS:

38.44: Resection of vessel with replacement, aorta, abdominal

38.34: Resection of vessel with anastomosis, aorta

39.25: Aorta-iliac-femoral bypass

39.71: Endovascular implantation of other graft in abdominal aorta

Coding lists used to define ruptured abdominal aortic aneurysm in HES and NIS datasets

ICD-10 Diagnostic codes for HES:

I713: Abdominal aortic aneurysm, ruptured
 I718: Aortic aneurysm of unspecified site, ruptured

ICD-9CM Diagnostic codes for NIS:

441.3: Abdominal aneurysm, ruptured
 441.5: Aortic aneurysm of unspecified site, ruptured

Table S2: Results of Conditional Regression Models

Table S2A: Tabulation of full results from conditional regression model for rate of intact aneurysm repair in England versus the USA.

Covariate	Odds Ratio	95% CI	p-value
England versus USA	0.49	0.48-0.49	<0.001
Age 65-69 vs 60-65	2.14	2.11-2.17	<0.001
Age 70-74 vs 60-65	3.10	3.06-3.14	
Age 75-79 vs 60-65	3.88	3.83-3.92	
Age 80-84 vs 60-65	3.68	3.64-3.73	
Age 85-89 vs 60-65	2.68	2.64-2.73	
Age 90 or older vs 60-65	1.12	2.11-2.17	
Gender (male vs. female)	4.39	4.35-4.43	< 0.001

Table S2B: Tabulation of full results from conditional regression model for rate of hospitalization for ruptured aneurysm in England versus the USA.

Covariate	Odds Ratio	95% CI	p-value
England versus USA	2.23	2.19-2.27	<0.001
Age 65-69 vs 60-65	2.09	2.01-2.17	<0.001
Age 70-74 vs 60-65	3.50	3.37-3.62	
Age 75-79 vs 60-65	5.18	5.00-5.35	
Age 80-84 vs 60-65	6.85	6.58-7.09	
Age 85-89 vs 60-65	9.01	8.70-9.35	
Age 90 or older vs 60-65	10.53	10.10-10.99	
Gender (male vs. female)	3.61	3.55-3.69	< 0.001

Table S2C: Tabulation of full results from conditional regression model for aneurysm-related mortality in England versus the USA.

Covariate	Odds Ratio	95% CI	p-value
England versus USA	3.60	3.55-3.64	<0.001
Age 65-69 vs 60-65	2.37	2.28-2.46	< 0.001
Age 70-74 vs 60-65	4.79	4.63-4.95	
Age 75-79 vs 60-65	8.55	8.26-8.85	
Age 80-84 vs 60-65	14.09	13.70-14.49	
Age 85-89 vs 60-65	20.83	20.41-21.74	
Age 90 or older vs 60-65	27.02	26.32-28.57	
Gender (male vs. female)	2.63	2.59-2.66	< 0.001

Table S3: Mean (SD) Diameter (cm) of aneurysms repaired in England and the USA, with comparison by country and operative modality using the Mann-Whitney U-Test.

	Endovascular	Open	All Repair (Endovascular and Open)	Wilcoxon-Mann-Whitney test
All England patients	6.27 (1.17)	6.57 (1.41)	6.38 (1.27)	<0.001
All US patients	5.71 (1.15)	6.16 (1.41)	5.82 (1.32)	<0.001
Wilcoxon-Mann-Whitney test	<0.001	<0.001	<0.001	

	Endovascular	Open	All Repair (Endovascular and Open)	Wilcoxon-Mann-Whitney test
England Males	6.30 (1.19)	6.61 (1.43)	6.41 (1.29)	<0.001
US Males	5.74 (1.19)	6.29 (1.48)	5.86 (1.34)	<0.001
Wilcoxon-Mann-Whitney test	<0.001	<0.001	<0.001	

	Endovascular	Open	All Repair (Endovascular and Open)	Wilcoxon-Mann-Whitney test
England Females	6.09 (0.98)	6.32 (1.26)	6.17 (1.08)	0.219
US Females	5.56 (0.99)	5.85 (1.17)	5.63 (1.20)	0.004
Wilcoxon-Mann-Whitney test	<0.001	<0.001	<0.001	

% of aneurysms repaired <5.5cm

	Endovascular	Open	All Repair (Endovascular and Open)	Chi-sq test
England (all)	10.09%	7.66%	9.26%	<0.001
US (all)	44.76%	29.08%	41.75%	<0.001
Chi-sq test	<0.001	<0.001	<0.001	

% of aneurysms repaired <5.5cm in men in USA and England

	Endovascular	Open	All Repair (Endovascular and Open)	Chi-sq test
England (males)	9.80%	6.94%	8.82%	0.004
US (males)	42.40%	23.73%	39.21%	<0.001
Chi-sq test	<0.001	<0.001	<0.001	

% of aneurysms repaired <5.0cm in women in USA and England

	Endovascular	Open	All Repair (Endovascular and Open)	Chi-sq test
England (males)	5.34%	3.51%	4.72%	0.507
US (males)	11.45%	19.36%	17.19%	0.042
Chi-sq test	<0.001	0.011	<0.001	

Figure S1: Probability density plots for aneurysm diameter at repair in England and the USA

Figure S1A: Probability density plot to show aneurysm diameter at time of endovascular repair in men in the USA and in England in 2013-14.

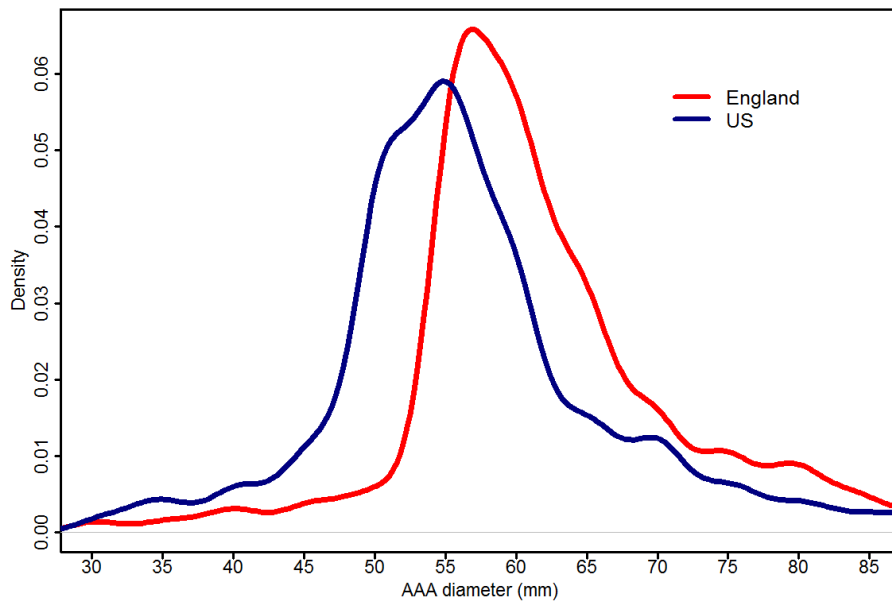


Figure S1B: Probability density plot to show aneurysm diameter at time of endovascular repair in women in the USA and in England in 2013-14.

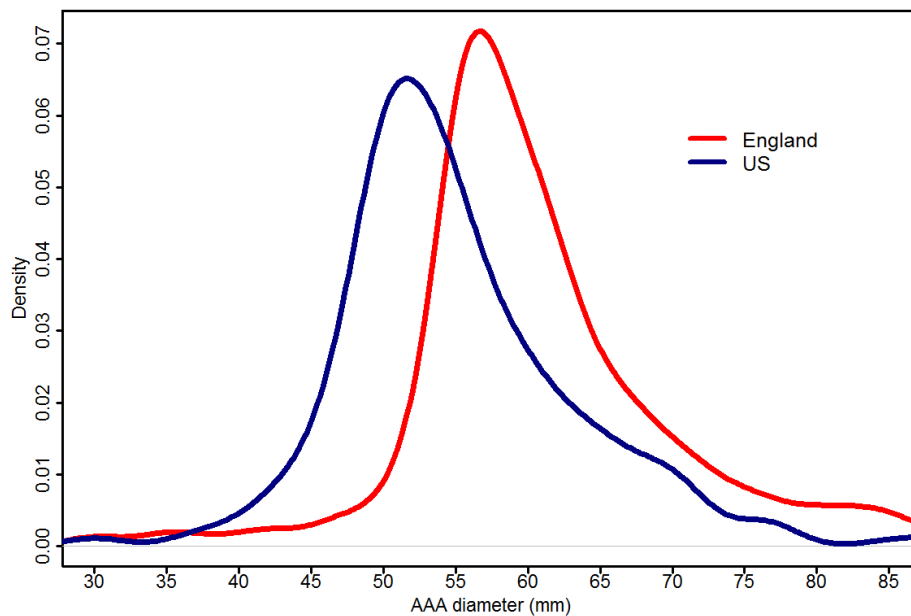


Figure S1C: Probability density plot to show aneurysm diameter at time of open repair in men in the USA and in England in 2013-14.

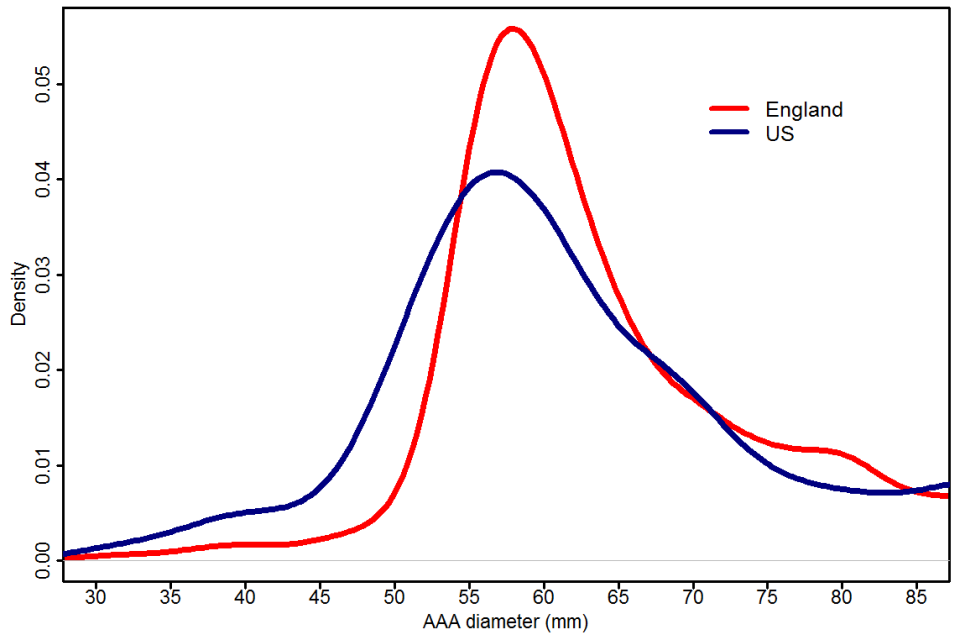


Figure S1D: Probability density plot to show aneurysm diameter at time of open repair in women in the USA and in England in 2013-14.

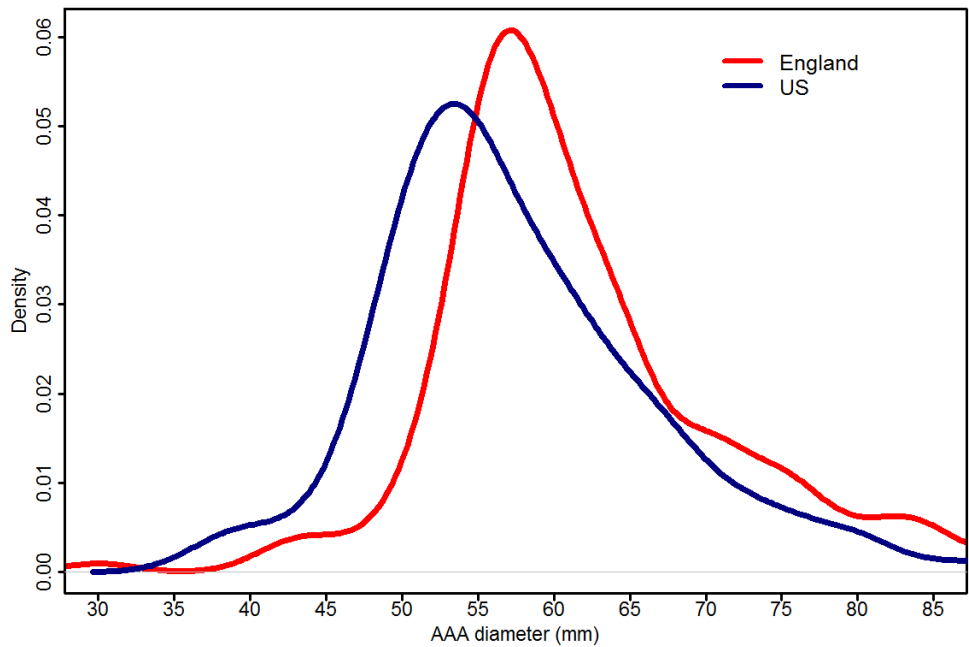


Figure S2 Probability density of aneurysms at each diameter for men enrolled in the UK National Abdominal Aortic Aneurysm Screening Programme 2009-2014; actual aneurysm diameter at repair in the USA and UK; and expected probability density for diameter at aneurysm repair in English screening patients if USA probability distribution were applied to English screening cohort.

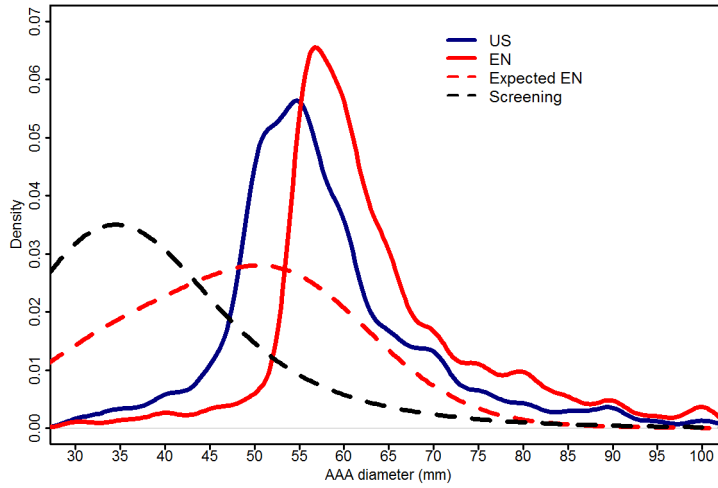


Figure S3 Density plots to illustrate the age distribution amongst patients undergoing aneurysm repair in England (HES) and the USA (NIS). Mean age at repair in the USA 73.5 +/- 3.6 years vs. mean age at repair in England 74.3 +/- 6.6 years.

Figure S3A: Density plot to illustrate the age distribution amongst males undergoing aneurysm repair in England (HES) and the USA (NIS)

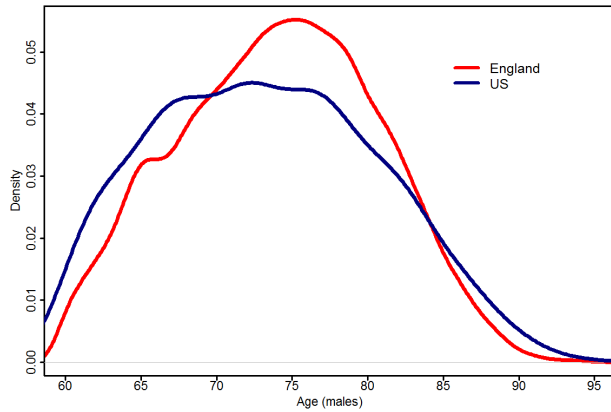


Figure S3B: Density plot to illustrate the age distribution amongst females undergoing aneurysm repair in England (HES) and the USA (NIS)

