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Socioeconomic Disparities in Surveillance and Follow-Up of Patients with Thoracic Aortic Aneurysm

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Abstract

Background: Thoracic aortic aneurysm is a significant risk factor for aortic dissection and rupture. Guidelines recommend referral of patients to a cardiovascular specialist for periodic surveillance imaging with surgical intervention determined primarily by aneurysm size. We investigated the association between socioeconomic status and surveillance practices in patients with ascending aortic aneurysms. Methods: We retrospectively reviewed records of 465 consecutive patients diagnosed between 2013-2016 with ascending aortic aneurysm [?]4cm on computed tomography scans. Primary outcomes were clinical follow-up with a cardiovascular specialist and aortic surveillance imaging within 2 years following index scan. We stratified patients into quartiles using the area deprivation index (ADI), a validated percentile measure of 17 variables characterizing socioeconomic status at the census block group level. Competing risks analysis was used to determine interquartile differences in risk of death prior to follow up with a cardiovascular specialist. Results: Lower socioeconomic status was associated with significantly lower rates of surveillance imaging and referral to a cardiovascular specialist. On competing risks regression, the ADI quartile with lowest socioeconomic status had lower hazard of follow-up with a cardiologist or cardiac surgeon prior to death (HR 0.46 [0.34, 0.62], $p<0.001$). Though there were no differences in aneurysm size at time of surgical repair, patients in the lowest socioeconomic quartile were more frequently symptomatic at surgery than other quartiles (92% vs 23-38%, $p<0.001$). Conclusion: Patients with lower socioeconomic status receive less timely follow-up imaging and specialist referral for thoracic aortic aneurysms, resulting in surgical intervention only when alarming symptoms are already present.

Introduction

Thoracic aortic aneurysm (TAA) represents a significant healthcare burden worldwide, with an estimated annual incidence of 5.3 per 100,000 persons/year, and is a significant risk factor for rupture, which has over 90% mortality.[1-3] Increased understanding of the natural history of TAA, with an average annual growth rate of 1mm/year, has led to recommendations for surveillance imaging at regular intervals to guide timing of surgical intervention.[4, 5] However, whether such periodic, guidelines-based clinical follow-up is implemented in clinical practice across patients of different sociodemographic strata remains unknown.

Several studies have demonstrated an association between cardiovascular health disparities and socioeconomic inequality.[6-9]Within cardiac surgery, lower socioeconomic status (SES) has been associated with greater mortality and morbidity after valve surgery and coronary artery bypass grafting (CABG).[10, 11]

In patients with TAA, it has been observed that lower SES and lack of health insurance is associated with greater acuity of presentation and higher mortality after aortic events (dissection and rupture).[12] However, it is unknown how SES affects the follow-up care and progression of TAAs prior to this.[12-14] Better characterizing this relationship may provide important insights into how socioeconomic inequality

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ultimately manifests as health outcome disparities for TAA patients. In the present study, we utilized the area deprivation index (ADI) as a measure of SES, which uses national census data to calculate a percentile measure of socioeconomic deprivation within in each census-block group.[15] We sought to determine the influence of ADI on whether patients receive appropriate surveillance follow-up after diagnosis of ascending thoracic aortic aneurysm (ATAA).

Patients and Methods

Patient Identification

We queried radiology reports from 21,336 chest computed tomography (CT) scans performed at a single tertiary care hospital between 2013-2016 on patients ages 50-85 for radiologic diagnosis of thoracic aortic dilatation or thoracic aortic aneurysm. 620 patients were identified with ascending thoracic aortic aneurysms (ATAA) whose records were further reviewed.

Area Deprivation Index

Area Deprivation Index (ADI) is a measure of SES, determined from 17 variables including income, education, employment, and housing quality collected by the United States Census Bureau.[15] By assigning a national percentile to each residential address at the Census Block level, ADI allows for quantification of SES on a scale of 1 to 100, where lower percentiles represent less deprivation (higher SES). National ADI percentile was collected for each patient's home address using the 2018 Neighborhood Atlas (University of Wisconsin School of Medicine and Public Health).

Inclusion/Exclusion Criteria

Of the 620 patients identified, we included 465 patients age [?]18 years old with ascending aortic size [?]4 cm on chest CT, including 4 patients with aortic dissection (2 acute, 2 chronic) on index scan. 18 patients were excluded due to ADI information being unavailable. 41 patients were excluded for residential address outside the state of Connecticut, due to concern for incomplete follow-up information in our institutional electronic medical record (EMR). 13 patients with only Post Office (P.O.) Box address were excluded. We excluded 10 patients who were lost to follow-up, defined as no listed encounters in the EMR within 4 years after the index CT scan, and 73 patients with mortality occurring less than 6 months after the index CT scan.

Demographics and Comorbidities

Demographic information included age, sex, weight, height, and race (White, Black, or other). Comorbidities at time of index CT scan included hypertension, dyslipidemia, diabetes mellitus, congestive heart failure, chronic kidney disease, myocardial infarction, liver disease, chronic obstructive pulmonary disease (COPD), active malignancy (thoracic vs extrathoracic), connective tissue disease, presence of bicuspid aortic valve, and prior cardiac surgical intervention.

Clinical follow-up, surveillance imaging, and outcomes

Follow-up care information was collected from the Yale-New Haven Health EMR, which encompasses 5 acute care hospitals in academic and community settings and over 120 outpatient clinics at satellite locations throughout the state of Connecticut. In addition, we utilized information from Care Everywhere (Natick, MA), which allows enrolled patients to share visit notes and imaging reports from outside healthcare institutions (in- and out-of-state) with our institutional EMR.

We reviewed the EMR to determine if patients were presently being followed for ATAA aneurysm by a cardiologist and/or cardiac surgeon, at the time of index CT scan. In patients without pre-existing relationships with these specialists, we recorded the dates of first encounter for ATAA monitoring. In addition, we determined whether patients received follow-up echocardiography and/or chest CT (with or without contrast), as recommended by consensus guidelines, and for what indication (aneurysm surveillance vs. unrelated) prior to 12 months and 24 months post-index scan.[4] These time intervals were chosen in light of evidence that

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annual surveillance imaging of moderate-size ATAA (<5cm) may be unwarranted.[16] We also determined whether patients had undergone surgical repair of their aneurysm during the study period, and if so, the size of the ATAA and presence of related symptoms (chest/back pain, dyspnea, dysphagia) at the time of surgical evaluation.

The date of the index CT scan was used as the initial time point for the follow-up. Length of clinical follow-up was defined as time elapsed from the date of index CT scan identifying ATAA to the date of first review of the EMR (March 1, 2021) in living patients, or date of mortality in deceased patients.

Statistical analysis

We ranked patients by national ADI percentile, and divided them into 4 equal-sized quartiles, where the lowest quartile (Q1) represents least socioeconomically deprived status, and highest quartile (Q4) represents most deprived.[10] To compare differences in demographics and comorbidities between ADI quartiles, we used Kruskal-Wallis rank sum test for continuous variables and Pearson chi-squared test or Fisher's exact test for categorical variables, as appropriate. Pairwise chi-squared test with nominal independence and Bonferroni correction was used for between-group differences. Two-sided Cochrane-Armitage test was used to compare occurrence of clinical and imaging follow-up between ADI quartiles.

Bivariate and multivariate generalized logistic regression were used to determine factors associated with occurrence of surveillance imaging (CT chest or echocardiogram) at or before 24 months following index CT scan. Variables with p-value <0.1 on bivariate analysis were included in the multivariate model.

Competing risks analysis, as described by Fine et al.,[17, 18] was used to model the effect of ADI quartile on time from index CT scan to first encounter with a cardiologist or cardiac surgeon for ATAA aneurysm, with the competing risk of death. Time to follow-up was defined as 0 for patients who were already established with either of these specialties. This methodology allows for visual representation of the subset of patients with pre-established follow-up prior to index scan, in which new first-time encounters do not apply. We performed competing risks regression adjusted for ADI quartile, age, sex, race, and ATAA size on index scan, factors which may influence a provider's decision to refer patients to a cardiovascular specialist. We defined statistical significance as$p$ <0.05. All data analysis was performed in R version 3.6.3 (R Foundation for Statistical Computing).

The Yale University Institutional Review Board approved this study and individual consent was waived (IRB 2000027551). The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cohort studies.

Results

Demographics, Comorbidities, and ADI

Mean clinical follow-up was 5.1 ± 2.1 years (**Table 1**) and median ATAA size on index CT scan was 4.3 (4.1, 4.5) cm (**Table 2**), and were similar between ADI quartiles. The mean age of the study population was 69.6 ± 9.2 years old, with the most disadvantaged quartile (Q4) being significantly younger (p=0.04). The majority of patients were male (77.8%), and there were no differences in the proportions of sex between quartiles. Race was predominately White (73.1%) but Black race was more common in more disadvantaged quartiles (p<0.001).

COPD was more prevalent in the most disadvantaged quartile (N=31, 27%), ranging from 13-16% in the lower ADI quartiles (p=0.02). There were also significant differences in presence of bicuspid aortic valve (BAV) and mitral valve pathologies between quartiles, but without clear directionality of these trends (p=0.03 and p=0.049, respectively). There were no significant differences between quartiles for other comorbidities obtained. Connective tissue disease was only present in 5 patients and was not included in statistical modeling.

Clinical Follow-Up

There were significant interquartile differences in rates of clinical follow-up (new or previously established)

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with a cardiologist or cardiac surgeon following diagnosis of ATAA aneurysm ($p<0.001$ and $p=0.002$, respectively), shown in **Figure 1** . Patients in the top three quartiles (Q1-Q3) were significantly more likely to have previously established follow-up with a cardiologist for their ATAA aneurysm, compared to those in Q4 ($p<0.001$). In addition, among those who were not already established with a cardiologist, rates of new encounters were similar between Q1, Q2, and Q3, at 36.3% (N=16), 46.3% (N=25), and 29.8% (N=17), respectively. However, only 16% (N=18) of previously unestablished patients in Q4 were seen by a cardiologist during the study period ($p<0.001$).

23.4% (N=109) of patients had previously established or new follow-up with a cardiac surgeon during the study period. ADI quartile was also significantly associated with follow-up with a cardiac surgeon ($p<0.002$), with statistically significant differences between the least disadvantage quartile (Q1) and most disadvantaged quartile (Q4) on pairwise testing (Q1: 33% vs. Q4: 16%).

47 (10.1%) patients underwent aortic repair surgery during the study period, at an average ATAA size of 5.0 (4.6, 5.2) cm (**Table 2**). There were no significant interquartile differences in ATAA size at time of surgery, but 92% (N=12) of patients in the most disadvantaged quartile were symptomatic at presentation for surgery, compared to only 25% (N=3) patients in the least disadvantage quartile ($p<0.001$).

Imaging Follow-Up

313 (67.3%) and 374 (80.4%) patients received at least one echocardiogram or chest CT within 12- and 24-months post-index scan, respectively (**Table 2**). Only 124 (33.2%) of patients imaged before 24 months were done so for thoracic aneurysm-related indications. Less disadvantaged quartiles were more likely to receive imaging at 24 months compared to the most disadvantaged quartile (Q2: 88% vs Q4: 71%, $p<0.001$). Conversely, active malignancy (4.12 [2.37, 7.57], $p<0.001$) and COPD (2.47 [1.21, 5.75], $p=0.011$) were associated with increased odds of imaging (**Table 3**). The trend for more disadvantaged quartiles being less likely to receive follow-up imaging persisted even after adjusting for family history of TAA, active malignancy, prior smoking history, congestive heart failure, and COPD on multivariate analysis ($p=0.006$ for Q4), **Table 3** .

Competing Risks Model

Among the 224 patients without previously established follow-up, follow-up with a cardiologist or cardiac surgeon occurred in 68 patients with a median time-to-event of 0.62 (0.13, 1.94) years (**Figure 2**). The competing event of death occurred in 60 patients with a median time-to-death of 1.76 (0.95, 3.02) years. In the least disadvantaged quartile (Q1), 11 patients reached the competing event of death in the study period with a median time-to-event of 1.91 (1.49, 3.08) years. In the most disadvantaged quartile (Q4), 26 patients reached the competing event of death with a median time-to-event of 1.5 (0.95, 2.29) years. On competing risks regression adjusted for age, ATAA size at index scan, active malignancy, sex, and race, only the most disadvantaged quartile was significantly less likely to receive follow-up prior to death (HR 0.46 [0.34, 0.62], $p<0.001$), compared to the least disadvantaged quartile (**Table 4**).

Comment

In this retrospective study of patients diagnosed with ATAA, we found that patients with lower socioeconomic status had lower rates of follow-up with a cardiovascular specialist and were less likely to receive timely follow-up imaging. In turn, these patients suffered worse outcomes in that they were more likely to present with symptoms at time of aortic surgery or die before ever being followed up. To date, there have been no studies that we know of examining the influence of SES on thoracic aortic aneurysm surveillance.

The majority of patients in our cohort had moderate-sized aneurysms (<5cm) without other significant risk factors (i.e. genetic syndromes), a population in which the appropriate interval for surveillance imaging is currently debated.[16, 19, 20]The 2010 ACCF/AHA Task Force guidelines recommend all patients with TAA be managed by a cardiologist or cardiac surgeon; however, they leave the imaging interval to the discretion of the provider.[4]While annual CT scan is reasonable after initial aneurysm detection or in genetically predisposed patients with stable ATAA size, we expect that intervals will be longer for those without associated risk

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factors. For this reason, we used a conservative interval of 2 years from last CT scan to evaluate whether patients were receiving regular surveillance with CT or echocardiography. We observed that patients in the ADI quartile with lowest SES were less likely to receive surveillance imaging for ATAA aneurysm within 2 years of last CT scan, even after adjusting for common comorbidities that warrant thoracic imaging. While we are unable to establish a causal relationship, the observed difference in successful referral to a cardiovascular specialist indicates the need for improved systems for establishing longitudinal follow-up in individuals with decreased access to care.

Several studies have linked lower patient socioeconomic status with disparities in cardiovascular healthcare.[6, 21, 22]While our study lacks information about previously employed measures of SES, such as insurance status and income level, the use of ADI in health outcomes research is growing as it provides a more comprehensive measure of disadvantaged status while offering greater granularity than estimates based on zip code alone. Within cardiac surgery, a study by Patrick et al. utilized ADI to show that lower SES is associated with receipt of fewer arterial conduits during CABG, resulting in worse long-term survival.[10] Lower income patients with coronary artery disease also face significant financial barriers to accessing routine care, such as medical checkups, Hgb A1c and lipid measurement, and antihypertensive treatment.[23] This is particularly important for patients with TAA as a higher incidence of TAAs has been observed in more socioeconomically deprived individuals, perhaps due to the greater prevalence of uncontrolled hypertension which is a known risk factor for adverse outcomes in TAA.[20, 24] Prior to this, the understanding of how socioeconomic barriers impact outcomes in patients with TAA was limited to only to survival after aortic dissection.[13, 14] This catastrophic outcome is avoidable with periodic monitoring and elective intervention.

Several previous studies have observed Black patients to experience poorer cardiovascular healthcare and outcomes.[25-27]The low number of non-white patients in our sample made it difficult to evaluate differences in care associated with race. The lack of statistically significant association between surveillance care and race may be due to the collinearity between ADI and race, with ADI being a variable accounting for a larger variation in the care.

Ultimately, in our study, patients of lower SES experienced inadequate aneurysm surveillance and follow-up and greater likelihood of presenting for surgery with symptoms. This finding is supported by another recent study of 51,282 patients from the Society for Thoracic Surgeons (STS) Database, which found that both uninsured as well as Medicaid patients were significantly more likely to undergo nonelective thoracic aortic operation than privately insured patients (RR 1.77 [1.70-1.83] and 1.18 [1.10-1.26], respectively).[12] Though our study lacks data on cause of mortality, the worrisome observation that 92% of patients in the lowest SES quartile (Q4) presented with symptoms is concerning for the subset of patients who may have died from aneurysm complications before having a chance to be seen.

Healthcare institutions must be proactive in engaging marginalized populations via interventions targeted at both patients and providers. This may take the form of automatically generated alerts to ordering providers when radiographic scans detect aneurysms above a certain size. In addition, public health initiatives should expand outreach to marginalized communities with education regarding the significant mortality associated with TAAs and the treatable nature of the disease.

Limitations

The present study is limited by its retrospective nature and that follow-up information was limited to data from a single healthcare network. As a result, it is possible that some patients were followed by cardiovascular specialists at outside institutions. We attempted to fill this gap using an automated inter-organization records exchange software (Care Everywhere), though we recognize that this is only available for patients who opt in. Furthermore, we did not assess whether patients were referred to a cardiologist or cardiac surgeon and were not seen. We did not include patient insurance status in our analysis, which would influence whether is patient is able to afford specialty care and imaging at regular intervals, regardless of income/SES. Lastly, cause of mortality is not reliably reported for patients dying outside the hospital setting, making it difficult to determine whether lack of surveillance resulted in increased mortality due to aortic-related events.

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Conclusion

Lower SES among ATAA patients is associated with decreased surveillance imaging, decreased follow-up with cardiovascular specialists, and greater odds of symptomatic presentation for aortic repair. Patients may benefit from systematic approaches to identify when inadequate aneurysm monitoring is occurring in order to improve the existing disparities in outcome.

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Disclosures

The authors have no disclosures to report.

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Tables

Table 1: Patient demographics and comorbidities by ADI quartile

	ADI Quartile (1=least disadvantaged)	**ADI Quartile (1=least disadvantaged)**
Characteristic	**1**, N = 117	**2**, N = 116
ADI (national percentile)	13 (6)	25 (5)
Clinical follow-up (years)	5.14 (2.12)	4.88 (2.03)
Age (years)	71 (8)	69 (9)
Sex		
Female	24 (21%)	17 (15%)
Male	93 (79%)	99 (85%)
Race		
Black	1 (0.9%)	5 (4.4%)
Other	21 (18%)	14 (12%)
White	93 (81%)	94 (83%)
Smoking	38 (32%)	55 (47%)
Hypertension	78 (67%)	85 (73%)
Diabetes Mellitus	18 (15%)	22 (19%)
Chronic Heart Failure	13 (11%)	11 (9.5%)
Chronic Kidney Disease	14 (12%)	12 (10%)
Connective Tissue Disease	2 (1.7%)	2 (1.7%)
Myocardial Infarction	6 (5.1%)	11 (9.5%)
Bicuspid Aortic Valve	4 (3.4%)	13 (11%)
Aortic Valve Disorder	17 (15%)	13 (11%)
Mitral Valve Disorder	12 (10%)	3 (2.6%)
Liver Disease	4 (3.4%)	4 (3.4%)
COPD	15 (13%)	15 (13%)
Dyslipidemia	59 (50%)	63 (54%)
Active Malignancy		
Thoracic	15 (13%)	18 (16%)
Extra-Thoracic	35 (30%)	30 (26%)
Prior cardiac surgery	20 (17%)	13 (11%)
FH of aneurysm	5 (4.3%)	7 (6.0%)

Table 1 Legend: Categorical variables are expressed as N (%) and continuous variables are expressed as mean (standard deviation). Increasing ADI corresponds with increasing socioeconomic deprivation.

ADI: area deprivation index, COPD: chronic obstructive pulmonary disorder, FH: family history

	ADI Quartile (1=least disadvantaged)	**ADI Quartile (1=least dis**
Characteristic	**1**, N = 117	**2**, N = 116
Indication for index scan		
Aneurysm-related	32 (27%)	23 (20%)
Unrelated/Incidental	85 (73%)	93 (80%)
ATAA size (cm)	4.30 (4.20,4.60)	4.30 (4.20,4.50)
Cardiology follow-up	89 (76%)[4]	87 (75%)[4]
Previously established	73 (62.4%)[4]	62 (53.4%)[4]
New[a]	16 (36.3%)[4]	25 (46.3%)[4]
Cardiac Surgery follow-up	39 (33%)[4]	27 (23%)
Imaging at 12 months (any indication)	88 (75%)[4]	86 (74%)

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	ADI Quartile (1=least disadvantaged)	**ADI Quartile (1=least dis**
Aneurysm-related	36 (41%)	18 (21%)
Unrelated/Incidental	52 (59%)	68 (79%)
Imaging at 24 months (any indication)	99 (85%)	102 (88%)[4]
Aneurysm-related	45 (45%)	29 (28%)
Unrelated/Incidental	54 (55%)	73 (72%)
Aortic Repair Surgery	13 (11%)	13 (11%)
ATAA size at surgery	4.90 (4.50,5.00)	5.00 (4.60,5.20)
Symptomatic at surgery	3 (23%)[4]	3 (23%)[4]

Table 2: Aneurysm characteristics and follow up outcomes by ADI Quartile

Table 2 Legend: Categorical variables are expressed as N (%) and continuous variables are expressed as median (interquartile range). Increasing ADI corresponds with increasing socioeconomic deprivation. Superscript numbers represent which quartiles were significantly different on post-hoc pairwise testing. Symptoms at surgery is defined as presence of chest/back pain, shortness of breath, or dysphagia at time of surgical repair of the aorta. Aneurysm-related and unrelated/incidental describe whether the imaging was performed specifically for aneurysm surveillance or for a separate indication.

ADI: area deprivation index, ATAA: ascending thoracic aortic aneurysm

a. proportion among patients who were not previously established (without prior appointments)

4. Statistically significant difference compared to Q4 on pair-wise testing.

Table 3: Univariate and multivariate analyses of factors associated with surveillance imaging prior to 24 months.

	Univariate	Univariate	Univariate		Multivariate	Multivariate	Multivariate
Characteristic	**OR**	**95% CI**	**p-value**		**OR**	**OR**	**95% CI**
ADI (quartile)							
2	1.32	0.63, 2.85	0.46		1.25	1.25	0.58, 2.76
3	0.66	0.33, 1.29	0.23		0.62	0.62	0.31, 1.25
4	0.44	0.23, 0.82	**0.012**		0.38	0.38	0.19, 0.76
Sex (male)	0.64	0.34, 1.14	0.14				
Age (years)	1.02	1.00, 1.05	**0.093**		1.01	1.01	0.99, 1.04
Race			0.2				
Black	—	—					
Other	0.39	0.11, 1.15					
White	0.47	0.14, 1.23					
ATAA Size (cm)	1.12	0.58, 2.33	0.7				
Family History of TAA	3.76	0.75, 68.4	0.12				
Malignancy	4.12	2.37, 7.57	**<0.001**		4.24	4.24	2.39, 7.94
Smoking History	1.47	0.92, 2.39	0.11		0.97	0.97	0.57, 1.66
Aortic Valve Disorder	1.25	0.61, 2.82	0.6				
Mitral Valve Disorder	1.02	0.40, 3.13	>0.9				
Hypertension	0.88	0.51, 1.46	0.6				
Diabetes Mellitus	1.26	0.71, 2.34	0.4				
Congestive Heart Failure	1.77	0.82, 4.40	0.2				
COPD	2.47	1.21, 5.75	**0.01**	**0.01**		2.87	1.29, 7.10
Chronic Kidney Disease	1.48	0.68, 3.71	0.3	0.3			
Bicuspid Aortic Valve	0.85	0.41, 1.96	0.7				

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Table 3 Legend: Surveillance imaging status was defined as having at least one echocardiogram or CT chest scan within 24 months post-index scan. We used a permissive p-value [?]0.10 for inclusion in the multivariate analysis. We also included smoking history in the multivariate analysis as this a common indication for CT chest imaging.

ADI: area deprivation index, ATAA: ascending thoracic aortic aneurysm, TAA: thoracic aortic aneurysm, COPD: chronic obstructive pulmonary disease, CI: confidence interval

Table 4: Adjusted competing risks regression of follow-up with a cardiovascular specialist versus death after index CT scan

Variable	OR	95% CI	P-value
ADI Quartile			
1	-	-	-
2	0.977	0.8, 1.19	0.82
3	0.834	0.67, 1.03	0.095
4	0.462	0.34, 0.62	**<0.001**
Age (years)	1	0.99, 1.01	0.6
AAo Size (cm)	1.65	1.35, 2.01	**<0.001**
Active Malignancy	0.67	0.55, 0.80	**<0.001**
Sex (female)	1.02	0.82, 1.27	0.85
Race			
White	-	-	-
Black	0.9	0.61, 1.34	0.6
Other	0.9	0.71, 1.14	0.38

Table 4 Legend: Competing risks regression adjusted for ADI quartile and clinical and demographic factors that would influence the decision to refer patients to a cardiologist and/or cardiac surgeon. Lowest socioeconomic quartile (Quartile 4), ascending aortic size, and active malignancy were identified as independent predictors of death prior to clinical follow-up.

OR: odds ratio, CI: confidence interval, ADI: area deprivation index, AAo: ascending aorta

Figure Legends

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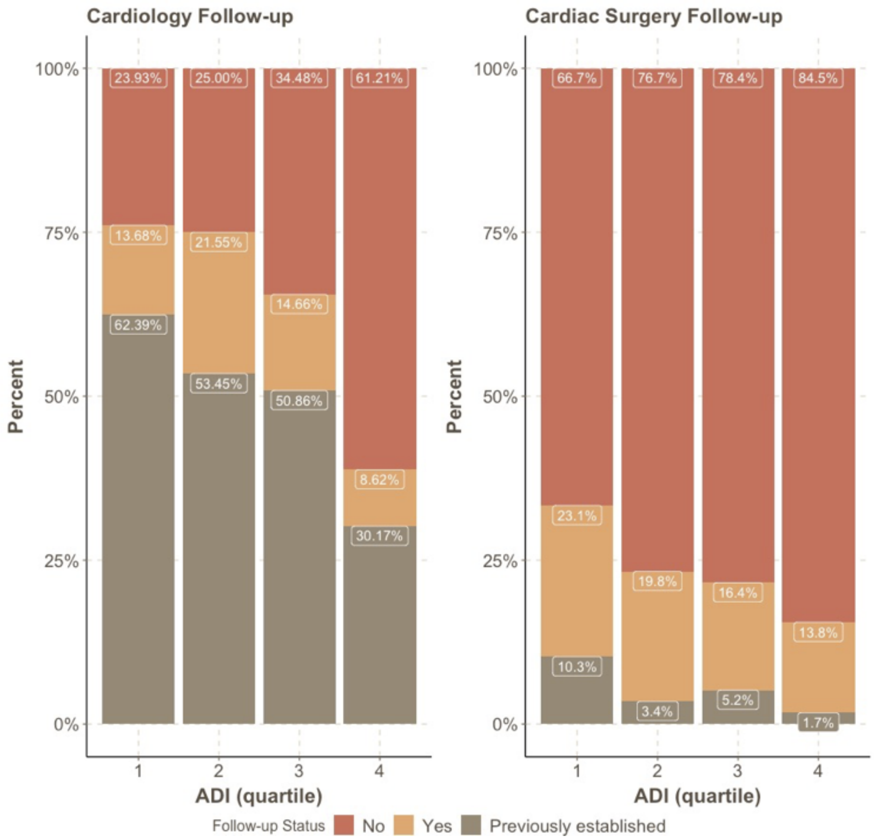

Figure 1: Cardiology and cardiac surgery follow-up status after index scan. Follow-up status is defined as having completed a consultation appointment with either a cardiologist or cardiac surgeon, specifically for aneurysm monitoring, at any date after the index computed tomography scan identifying ascending thoracic aortic aneurysm. Those with records of having attended an appointment with either specialty in the past for aneurysm monitoring were included in a separate category ('Previously established'). Increasing ADI quartile corresponds with increasing socioeconomic deprivation. Percentages represent proportion of patients within each category by quartile.

ADI: area deprivation index

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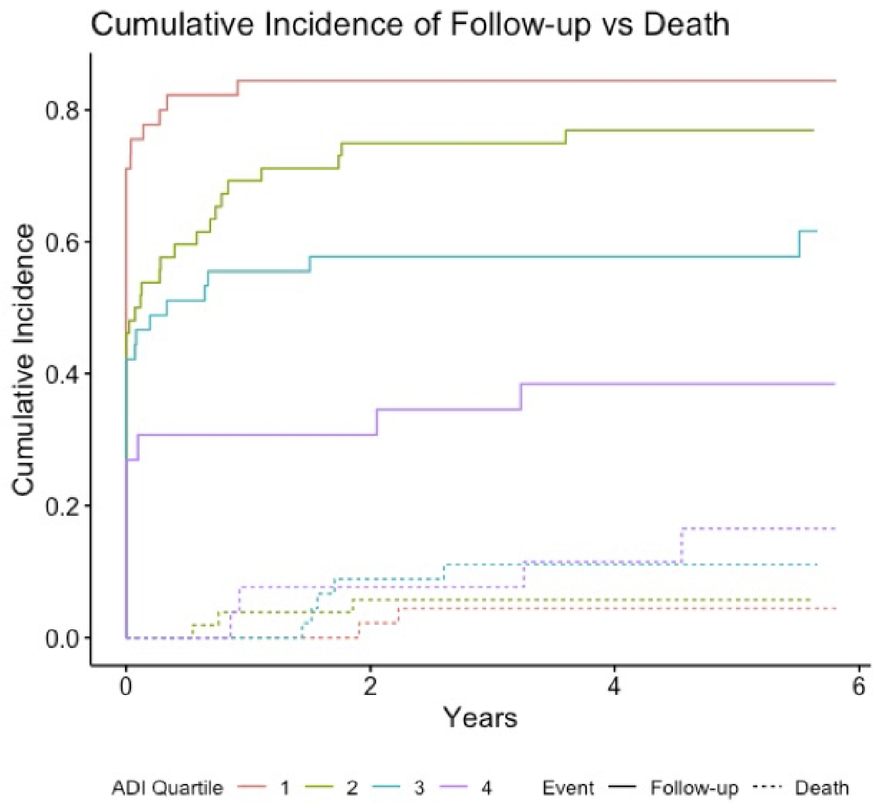

Figure 2: Cumulative incidence function of follow-up versus death for each ADI Quartile. Generated from unadjusted competing risks analysis of time-to-follow-up with a cardiologist or cardiac surgeon following index scan identifying ATAA (solid line) against the competing risk of death before follow-up (dotted line). Patients who already had previously established follow-up were included with a time-to-follow-up of 0. The third and fourth ADI quartiles had significantly greater hazard of death before follow-up compared to the first ADI quartile.

ADI: area deprivation index, ATAA: ascending thoracic aortic aneurysm