openheart

Impact of gender, ethnicity and social deprivation on access to surgical or transcatheter aortic valve replacement in aortic stenosis: a retrospective database study in England

Caoimhe T Rice ,[1] Sophie Barnett ,[2] Shea P O'Connell,[1] Enoch Akowuah ,[3] Clare E Appleby,[4] John B Chambers ,[5] Benoy N Shah ,[6] Daniel J Blackman[7]

To cite: Rice CT, Barnett S, O'Connell SP, *et al*. Impact of gender, ethnicity and social deprivation on access to surgical or transcatheter aortic valve replacement in aortic stenosis: a retrospective database study in England. *Open Heart* 2023;**10**:e002373. doi:10.1136/openhrt-2023-002373

Received 30 May 2023
Accepted 7 August 2023

[1]Specialty EMR Data, Corevitas, London, UK
[2]Medtronic International Trading Sarl, Tolochenaz, Switzerland
[3]South Tees Hospitals NHS Foundation Trust, Middlesbrough, UK
[4]Liverpool Heart and Chest Hospital NHS Foundation Trust, Liverpool, UK
[5]Guy's and St Thomas' NHS Foundation Trust, London, UK
[6]University Hospital Southampton NHS Foundation Trust, Southampton, UK
[7]Department of Cardiology, Leeds Teaching Hospitals NHS Trust, Leeds, UK

Correspondence to
Sophie Barnett; sophie.barnett@medtronic.com

ABSTRACT

Objective To assess gender, ethnicity, and deprivation-based differences in provision of aortic valve replacement (AVR) in England for adults with aortic stenosis (AS).

Methods We retrospectively identified adults with AS from the English Hospital Episode Statistics (HES) between April 2016 and March 2019 and those who subsequently had an AVR. We separately used HES-linked Clinical Practice Research Datalink (CPRD) to identify people with AVR and evaluate the timeliness of their procedure (CPRD-AVR cohort). ORs for AVR in people with an AS diagnosis were estimated using multivariable logistic regression adjusted for age, region and comorbidity. AVR was considered timely if performed electively and without evidence of cardiac decompensation before AVR.

Results 183 591 adults with AS were identified in HES; of these, 31 436 underwent AVR. The CPRD-AVR cohort comprised 10 069 adults. Women had lower odds of receiving AVR compared with men (OR 0.65; 95% CI 0.63 to 0.66); as did people of black (OR 0.70; 95% CI 0.60 to 0.82) or South Asian (OR 0.75; 95% CI 0.69 to 0.82) compared with people of white ethnicities. People in the most deprived areas were less likely to receive AVR than the least deprived areas (OR 0.8; 95% CI 0.75 to 0.86). Timely AVR occurred in 65% of those of white ethnicities compared with 55% of both those of black and South Asian ethnicities. 77% of the least deprived had a timely procedure compared with 58% of the most deprived; there was no gender difference.

Conclusions In this large, national dataset, female gender, black or South Asian ethnicities and high deprivation were associated with significantly reduced odds of receiving AVR in England. A lower proportion of people of minority ethnicities or high deprivation had a timely procedure. Public health initiatives may be required to increase clinician and public awareness of unconscious biases towards minority and vulnerable populations to ensure timely AVR for everyone.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Aortic valve replacement (AVR) is a life-saving procedure for symptomatic severe aortic stenosis (AS), which relieves symptoms, increases life expectancy and improves quality of life.
⇒ Little is known about the rate of AVR provision by gender, race or social deprivation level in the National Health Service across England.

WHAT THIS STUDY ADDS

⇒ The adjusted odds of receiving an AVR among people with AS in England are lower for women than men, people of black or South Asian ethnicities compared with people of white ethnicities, and the most versus least socially deprived people.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Further research and public health initiatives to understand and address inequalities in the timely provision of AVR are important and should be prioritised in England.

INTRODUCTION

Aortic stenosis (AS) is the valve disease most commonly requiring intervention in England.[1] Between one-fifth and one-quarter of people with severe or very severe AS will die within 5 years without intervention.[2] Aortic valve replacement (AVR), either transcatheter or surgical (TAVI or SAVR), is standard care in the UK.[1 3 4] Notably, the National Institute of Health and Care Excellence recommends that all people with severe symptomatic AS, as well as other specific indications, are offered AVR[3]; consistent with European and US clinical guidelines.[1 4]

Severe AS exposes the left ventricle to chronic pressure overload, leading to progressive left ventricular (LV) dysfunction

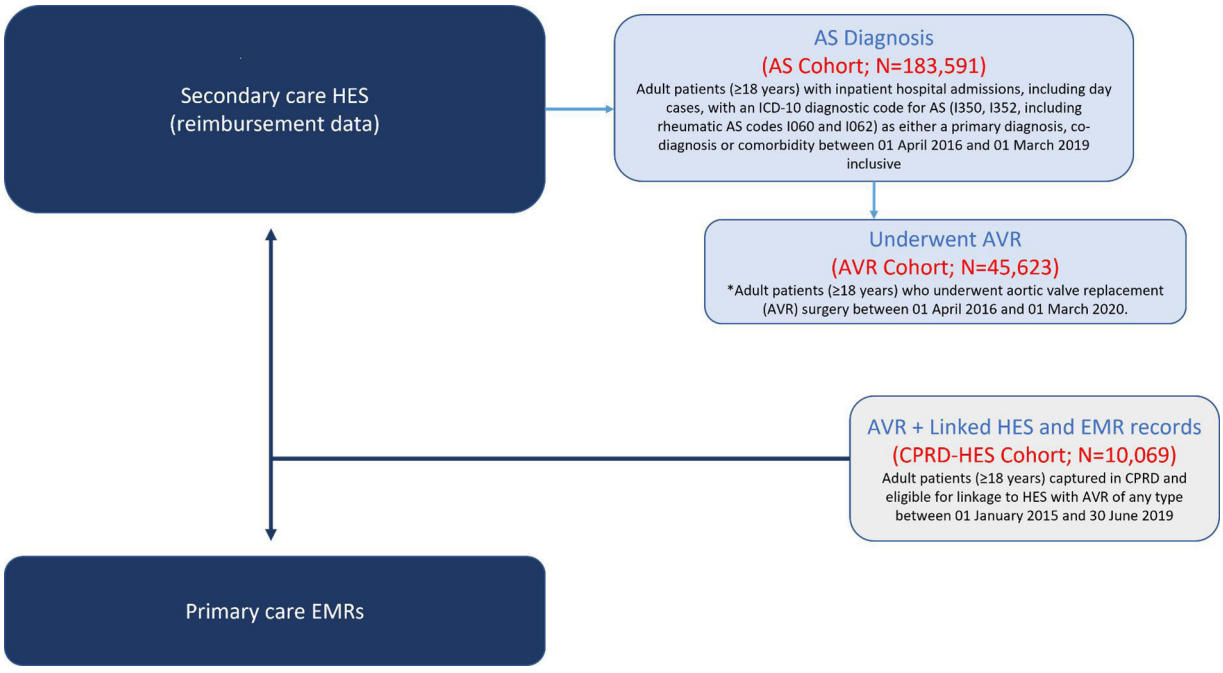

Figure 1 Study design. *The additional year of data compared with the AS cohort was added to allow for lagged AVR compared with AS diagnosis. AS, aortic stenosis; AVR, aortic valve replacement; CPRD, Clinical Practice Research Datalink; eMR, electronic medical record; HES, Hospital Episode Statistics.

which may not recover fully after intervention if this is delayed. It is therefore imperative to monitor asymptomatic people carefully and refer them for early intervention with even minor symptoms or early LV dysfunction. Indeed, a long wait for AVR often leads to clinical deterioration, acute hospital admission or even death.[5]

Gender differences in the treatment of valvular heart disease are underappreciated but gaining more focus.[6–8] Recent European Society of Cardiology guidance calls for measures to ensure both sexes receive equitable care to reduce higher female mortality, resulting from late diagnosis, referral and treatment.[1] In addition, the UK government has recently published the Women's Health Strategy for England,[7] committing to 'eradicating deep-seated biases and driving forward the system-level changes needed to close the gender health gap'.

We are unaware of any UK-based research reporting differences in the provision of AVR for the treatment of AS across ethnicities. Most of the existing literature is based on US populations[8 9] where the healthcare system differs significantly from the UK (ie, UK government-sponsored system vs US fee-for-service model; and the US insured vs uninsured cost differences). However, US data demonstrate substantial disparities in access to AVR for people of different ethnicities.[10 11]

The impact of social deprivation status on provision of AVR in the UK has not been previously evaluated. General differences in health and care due to deprivation are demonstrated by the gap in life expectancy between individuals from the most and least deprived areas which is 9.7 years for males and 7.9 years for females,[12] and widens to 19.3 years and 18.6 years, respectively when considering healthy life expectancy.[13] Studies have shown an association between socioeconomic deprivation and cardiovascular morbidity and mortality,[14] including a UK-based study showing that the risk of mortality from all circulatory disease and ischaemic heart disease increases with deprivation.[15] Furthermore, a large-scale community study, OxVALVE, identified an increased incidence of undiagnosed valvular heart disease among more deprived socioeconomic groups.[16]

Whether gender, ethnicity and deprivation-based differences affect the provision of aortic valve intervention in England is unknown. Therefore, we used a large English dataset of patients with a hospital diagnosis of AS, to analyse the odds of receiving surgical or transcatheter AVR for women, people of different ethnicities, and deprivation levels, as well as to evaluate the timeliness of intervention.

METHODS

Study design

This was a retrospective observational cohort study to assess differences in access to AVR for people with known AS by gender, ethnicity and social deprivation status. We used national person-level reimbursement data from England's Hospital Episode Statistics (HES) in secondary care to identify a cohort of people with diagnosed AS (HES-AS cohort) and a cohort who had received AVR (HES-AVR cohort). These cohorts were not mutually exclusive and allowed us to determine which people with AS went on to have AVR. To further evaluate the care pathway to AVR, we identified a smaller, representative cohort of AVR people from the Clinical Practice

Table 1 Demographic summary per cohort

Metrics	HES-AS cohort	HES-AVR cohort	CPRD-HES AVR cohort*
Total number of patients	183 591	45 623	10 069
Age on inclusion, mean (SD)	79.01 (11.17)	72.46 (12.05)	71.36 (13.29)
Gender†, N (%)			
†Male	96 187 (52.39%)	28 749 (63.01%)	6376 (63.32%)
Female	87 396 (47.60%)	16 873 (36.98%)	3693 (36.68%)
Total time in cohort (patient days)‡	114 727 493	27 836 972	7 182 754
Follow-up time (patient months), mean (SD)	20.83 (14.21)	20.34 (13.88)	23.78 (15.83)
Charlson Comorbidity Index distribution			
0	38 437 (20.94%)	9728 (21.32%)	1800 (17.88%)
1	42 361 (23.07%)	12 355 (27.08%)	2355 (23.39%)
2	34 625 (18.86%)	9179 (20.12%)	1924 (19.11%)
3	25 755 (14.03%)	6080 (13.33%)	1486 (14.76%)
4	17 330 (9.44%)	3754 (8.23%)	890 (8.84%)
5	11 200 (6.1%)	2161 (4.74%)	652 (6.48%)
6+	13 883 (7.56%)	2366 (5.19%)	962 (9.55%)
IMD quintile distribution§			
1—most deprived	30 293 (16.5%)	6426 (14.09%)	1429 (14.19%)
2	34 858 (18.99%)	8103 (17.76%)	1799 (17.87%)
3	39 693 (21.62%)	9629 (21.11%)	2085 (20.71%)
4	40 481 (22.05%)	10 432 (22.87%)	2239 (22.24%)
5—least deprived	36 304 (19.77%)	9800 (21.48%)	2489 (24.72%)
Unknown	1962 (1.07%)	1233 (2.7%)	28 (0.28%)
Ethnicity breakdown (HES)¶			
White (Irish, British, Traveller)	160 299 (87.31%)	35 021 (76.76%)	
South Asian (Pakistani, Bangladeshi, Indian, any)	4722 (2.57%)	1080 (2.37%)	
Black (Caribbean, African, any)	1663 (0.91%)	365 (0.80%)	
Mixed (any mixed ethnicity)	385 (0.21%)	127 (0.28%)	
Other (any other ethnic group, eg, Chinese, Arab)	1779 (0.97%)	470 (1.03%)	
Not stated/unknown	14 743 (8.03%)	8560 (18.76%)	
Ethnicity breakdown (CPRD)¶			
¶White (Irish, British)			9398 (93.34%)
South Asian (Pakistani, Bangladeshi, any)			282 (2.80%)
Black (Caribbean, African, any)			97 (0.96%)
Mixed (any mixed ethnicity)			38 (0.38%)
Other (any other ethnic group, eg, Chinese, Arab, Roma or Irish Traveller)			113 (1.12%)
Unknown			101 (1.00%)
AVR admission method**			
**Elective	25 307 (13.78%)	35 208 (77.17%)	7560 (75.08%)
Non-elective	6127 (3.34%)	10 412 (22.82%)	2508 (24.91%)
Other	**S**	**S**	**S**
AVR not recorded in data period	152 155 (82.88%)		
AVR procedure type‡			
SAVR	20 610 (11.23%)	31 538 (69.13%)	7533 (74.81%)
TAVI	10 098 (5.5%)	12 957 (28.4%)	2536 (25.19%)

Continued

Table 1 Continued

Metrics	HES-AS cohort	HES-AVR cohort	CPRD-HES AVR cohort*
Undefined	517 (0.28%)	815 (1.79%)	
Surgical bailout	211 (0.11%)	313 (0.69%)	
AVR not recorded in data period	152 155 (82.88%)		
Unknown	1405 (0.77%)	509 (1.12%)	

S denotes cells suppressed due to small patient numbers (<5) to prevent identification of patients.
*CPRD covers approximately 20% of the English population; therefore, there are fewer people.
†The stated gender of the people on their index date, presented as a number and percentage of the respective cohort.
‡The type of the person's index AVR presented as the number of people and percentage of the respective cohort.
§The distribution of IMD quintiles captured on the person's index dates, presented as the number of people and percentage of the overall cohort.
¶HES and CPRD have different ethnicity categories. Where possible, we have aligned similar ethnicity descriptions. Discrepancies may be due to differences in recording practices between primary and secondary care, eg, self-identification in primary care.
**The admission method of the person's index AVR, presented as the number of people and percentage of the respective cohort.
AS, aortic stenosis; AVR, aortic valve replacement; CPRD, Clinical Practice Research Datalink; HES, Hospital Episode Statistics; IMD, Index of Multiple Deprivation; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve replacement.

Research Datalink (CPRD) which provides primary care electronic medical records (eMRs) linked with HES.

People were eligible for the HES-AS cohort if they were ≥18 years and had an ICD-10 diagnostic code for AS (I350, I352, including rheumatic AS codes I060 and I062) recorded during an inpatient (IP) hospital admission, which includes day cases, and ambulatory care, between 1 April 2016 and 1 March 2019, inclusive. AS diagnosis codes could be recorded as either a primary diagnosis, codiagnosis or comorbidity. In practice, useful diagnostic information is coded against few (3%) of outpatient (OP) appointments therefore, only IP records were considered for identification of AS.[17]

For the HES-AVR cohort, we included adults (≥18 years) who underwent AVR intervention between 1 April 2016 and 1 March 2020 from IP admissions using OPCS-4 codes K262, K263 and K264. It should be noted that the HES-AVR cohort has an additional year of data to allow for AVR which inevitably occurs later than the diagnosis of AS. People undergoing multiple valve replacement in the same admission and people with previous AVR procedure were excluded, as were people who required an urgent or emergent AVR due to endocarditis or aortic root dissections. An overview of the three study cohorts is depicted in figure 1.

The linked CPRD-HES cohort was obtained from CPRD and consisted of adult people (≥18 years) registered with a general practice contributing to CPRD and eligible for linkage to HES with an AVR of any type between 1 January 2015 and 30 June 2019. AVRs were identified from their HES admissions using the same AVR procedure codes as the HES-AVR cohort.

For all cohorts, any birth or maternity activity was excluded from the dataset. Patients with unknown sex, unknown age or age >120 were also excluded from the dataset. HES data was used as observed. All ethnicity, gender, Index of Multiple Deprivation (IMD) categories were as stated on the relevant index. No matching or weighting of the populations was performed.

Outcome measures

The odds of women receiving AVR were compared with men to calculate the OR; each ethnic group was compared with a white ethnic reference group, and each deprivation quintile was compared with the least deprived quintile using IMD. Both gender and ethnicity fields in HES are listed as self-reported in the data dictionary. Where appropriate, similar ethnicities were amalgamated as per the grouping of ethnicity suggested by HM government to provide meaningful insight and reduce the need for small number suppression.[18]

IMD is a composite measure of relative deprivation in small areas or neighbourhoods known as Lower-layer Super Output Areas in England. It is produced by the Ministry of Housing, Communities and Local Government and is based on seven domains of income, employment, health deprivation and disability, education, skills and training, crime, barriers to housing and services, and living environment, see English indices of deprivation 2019—GOV.UK (www.gov.uk) for more details. Areas are ranked from most deprived to least deprived, and individual person IMD is reported as IMD quintile, where quintile 1 is the least deprived areas and 5 is the most deprived.[19] IMD is an indexed variable, and where there is no difference due to deprivation, 20% of the given population should be observed in each quintile.

To evaluate the timing of AVR for people of different gender, ethnicities and deprivation levels, we looked at the number and proportion of people for whom the procedure was timely, that is, performed during an elective (scheduled) admission and without evidence of cardiac decompensation on or before AVR, or delayed that is, performed during a non-elective (unscheduled/urgent) admission or with evidence of cardiac decompensation on

or before AVR. In determining 'delayed' AVR, we assume that the preferred path to AVR is an elective admission prior to cardiac decompensation. To this end, we have excluded people with medical emergencies necessitating urgent AVR that is, endocarditis or aortic root dissection, to avoid misclassifying appropriate emergency treatment as 'delayed'. Elective and non-elective AVR admissions were identified from their HES admission type. Cardiac decompensation was defined as a non-elective admission due to aortic valve disease or congestive heart failure admission (ICD-10 diagnosis codes I50, I11.0, I13.0 or I11.3), after AS diagnosis and on or before the date of AVR procedure. We report the number and proportion with timely or delayed procedures by gender, ethnicity, and socioeconomic deprivation.

Statistical analysis

The OR for receiving an AVR among the HES-AS cohort was estimated using multivariable logistic regression. All ORs were adjusted for age at AS diagnosis (continuous), HES geographical region for England and comorbidity as assessed by ordinal Charlson Comorbidity Index score. ORs were also adjusted for gender, ethnicity and deprivation quintile as described by IMD, however, we did not adjust where these were the explanatory variable in the model.

Due to the near-complete coverage of HES for hospital-treated conditions, we treated no recorded evidence of the comorbidities of interest as equivalent to the absence of the condition or treatment. No imputation was performed. Where categories such as ethnicity or IMD were recorded as 'not stated' or 'not known', they were analysed in these categories. Where gender, a key identifying variable, was 'not stated 'or 'not known', these patients were excluded from the analysis. All analyses were conducted using R V.4.2.1.

RESULTS

Person demographics and cohorts

A cohort of 185 391 had an HES record of AS during an inpatient admission, of whom 31 436 subsequently underwent an AVR procedure out of the 45 623 identified with an AVR procedure (HES-AVR cohort). The linked CPRD-HES dataset comprised 10 069 AVR people. A summary of demographic information by cohort (HES-AS, HES-AVR and CPRD-HES) is shown in table 1. Across all three cohorts, most were from a white British/Irish ethnic background (87%, 77% and 93%, respectively), with a slightly lower proportion of women than men (48%, 37% and 37%, respectively) in each cohort. IMD quintiles indicated lower proportions in the most deprived quintile than the expected 20% if there was no difference with deprivation (17%, 14% and 14%, respectively) across all cohorts.

Odds of AVR provision

Overall, women with AS were significantly less likely to receive AVR than men (OR 0.65; 95% CI 0.63 to 0.66, p<0.001), figure 2. People of black or South Asian ethnicities were also significantly less likely to receive AVR than people from a white ethnic background (OR 0.70; 95% CI 0.60 to 0.82 and OR 0.75; 95% CI 0.69 to 0.82, respectively, p<0.001 for both). In addition, people in

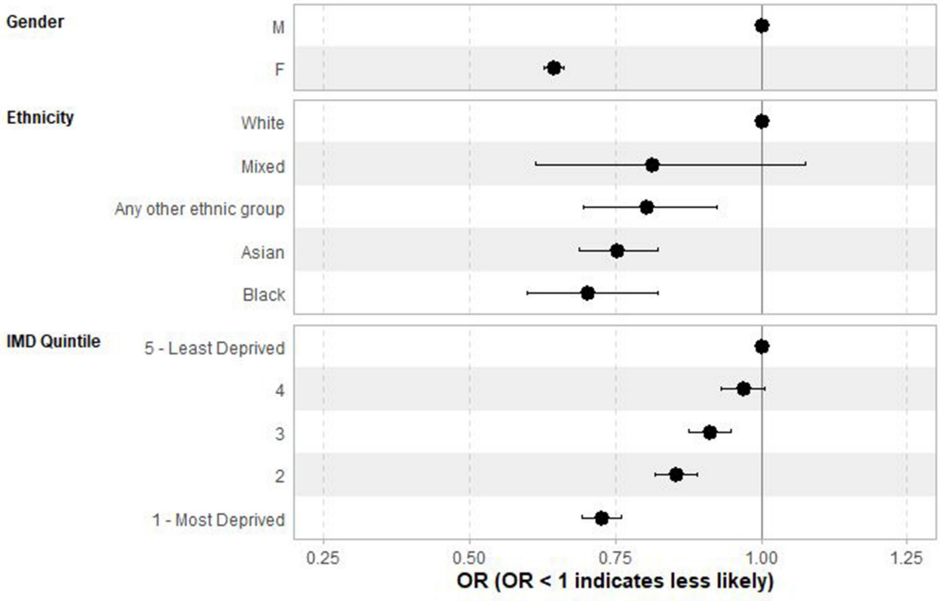

Figure 2 ORs of receiving aortic valve replacement (AVR) for people who received a diagnostic code for aortic stenosis (AS) in hospital (ie, HES-AS cohort), were calculated for women relative to men, all ethnicities relative to white ethnicity and deprivation quintiles compared with the least deprived. ORs were adjusted for age at diagnosis, region of England and Charlson Comorbidity Index score. ORs were also adjusted for gender, ethnicity and deprivation quintile as described by IMD, however, we did not adjust where these were the explanatory variable in the model. F, female; HES, Hospital Episode Statistics; IMD, Index of Multiple Deprivation; M, male.

Table 2 Odds of receiving AVR by gender, ethnicity and deprivation quintile

	Total patients	Number and percentage of AS patients with an AVR procedure	Unadjusted ORs of accessing AVR following an AS diagnosis				Adjusted ORs of accessing AVR following an AS diagnosis			
			OR	Lower 95% CI	Upper 95% CI	P value	OR	Lower 95% CI	Upper 95% CI	P value
Gender										
Male	95 611	19 450.0 (20.34%)	–	–	–	–	–	–	–	–
Female	86 950	11 756.0 (13.52%)	0.61	0.6	0.63	**<0.001**	0.65	0.63	0.66	**<0.001**
Ethnicity										
White	159 370	26 323.0 (16.52%)	–	–	–	–	–	–	–	–
Black	1663	197.0 (11.85%)	0.68	0.59	0.79	**<0.001**	0.7	0.6	0.82	**<0.001**
Asian	4718	704.0 (14.92%)	0.89	0.82	0.96	**0.004**	0.75	0.69	0.82	**<0.001**
Mixed	384	68.0 (17.71%)	1.09	0.84	1.41	0.53	0.81	0.61	1.08	0.15
Chinese	147	17.0 (11.56%)	0.66	0.40	1.10	0.11	0.6	0.35	1.01	0.06
Any other ethnic group	1629	265.0 (16.27%)	0.98	0.86	1.12	0.79	0.8	0.7	0.92	**0.002**
Not stated	10 326	2287.0 (22.15%)	1.44	1.37	1.51	**<0.001**	1.16	1.1	1.22	**<0.001**
Not known	4324	1345.0 (31.11%)	2.28	2.14	2.44	**<0.001**	1.82	1.7	1.95	**<0.001**
Index of Multiple Deprivation (IMD)										
IMD quintile 5 (least deprived)	30 288	4322.0 (14.27%)	–	–	–	–	–	–	–	–
IMD quintile 4	34 852	5651.0 (16.21%)	0.95	0.92	0.98	**0.005**	0.97	0.93	1.01	0.11
IMD quintile 3	39 643	6826.0 (17.22%)	0.89	0.86	0.92	**<0.001**	0.91	0.88	0.95	**<0.001**
IMD quintile 2	0 461	7345.0 (18.15%)	0.83	0.80	0.86	**<0.001**	0.85	0.82	0.89	**<0.001**
IMD quintile 1 (most deprived)	36 296	6872.0 (18.93%)	0.71	0.68	0.74	**<0.001**	0.73	0.69	0.76	**<0.001**
Unknown	1021	190.0 (18.61%)	0.98	0.83	1.15	0.79	0.89	0.72	1.09	0.25

Unadjusted ORs are produced within group only—for example, comparing the odds of receiving aortic valve replacement (AVR) for males versus females, without any consideration for a difference in ethnicity. ORs were also adjusted for gender, ethnicity and deprivation quintile, however, we did not adjust where these were the explanatory variable in the model. Other covariates included in the adjusted analyses were age at aortic stenosis (AS) diagnosis, region and Charlson Comorbidity Index score.
Bold text denotes statistical significance at at least the level of p≤0.05.

the most deprived (OR 0.73; 95% CI 0.69 to 0.76) second most deprived (OR 0.85; 95% CI 0.82 to 0.89) and third most deprived quintiles (OR 0.91; 95% CI 0.88 to 0.95) had a significantly reduced odds of receiving an AVR than those in the least deprived quintile (p<0.001 for all). All adjusted and unadjusted ORs are reported in table 2.

Timely versus delayed pathway to AVR

The pathway data (timely AVR, delayed AVR or other) for people from the CPRD-AVR cohort by gender, ethnicity and IMD are reported in tables 3 and 4.

In the CPRD-HES AVR cohort, delayed AVR occurred in a higher proportion with black (32%), or South Asian (36%) than white ethnicities (28%), or in the most deprived quintile (33%) than in the least deprived quintile (26%) (figure 3). Conversely, a higher proportion with white ethnicities (65%) received timely AVR than with black or South Asian ethnicities (both 55%). The proportion with timely AVR was 68% in the least deprived quintile compared with 58% for those in the most deprived. No difference in receiving timely or delayed AVR was observed by gender.

However, the median time from the first secondary care cardiovascular service touch point (either as an IP or OP) to receiving AVR was 3 months longer for women than men. Women also had a higher median number of primary care consultations (41) than men (34) in the 48 months prior to AVR (table 5).

DISCUSSION

The main findings of this study are that women, people of black or South Asian ethnicities, and people from deprived areas with AS were less likely to receive AVR than men, people of white ethnicities and those in the least deprived areas. To the best of our knowledge, this is the first study assessing differences in provision of and pathway to AVR for patients with AS in England. The

Table 3 Proportion of people receiving timely AVR, delayed AVR or AVR via a different pathway for each gender and ethnicity group for the CPRD-HES cohort

	Gender		Ethnicity						
	Male	Female	White (British, Irish, any other white background)	Black (black British, Caribbean, African)	South Asian (Indian, Pakistani, Bangladeshi)	Chinese	Other Asian	Mixed ethnicity	Any other background or unknown
Total*, n	6376	3693	9398	137	205	11	77	38	203
Timely AVR†, n (%)	4075 (63.91%)	2456 (66.5%)	6125 (65.17%)	75 (54.74%)	113 (55.12%)	5 (45.45%)	47 (61.04%)	28 (73.68%)	138 (67.98%)
Delayed AVR‡, n (%)	1819 (28.53%)	1051 (28.46%)	2667 (28.38%)	44 (32.12%)	73 (35.61%)	**S**	19 (24.68%)	5 (13.16%)	58 (28.57%)
Other AVR§, n (%)	482 (7.56%)	186 (5.04%)	606 (6.45%)	18 (13.14%)	19 (9.27%)	**S**	11 (14.29%)	5 (13.16%)	7 (3.45%)

S denotes cells suppressed due to small patient numbers (<5) to prevent identification of patients, as required by CPRD.
*The total number of people in each respective group, used as the denominator for the stated percentages from the CPRD-HES AVR cohort.
†Defined as any person who has undergone an elective AVR, AND who does not have a non-elective admission to hospital due to aortic valve disease or congestive heart failure (HF), in the 12 months prior to their index procedure, AND has a record of an outpatient appointment within the cardiology or cardiac surgery treatment specialties, and/or a record of an echocardiogram prior to their index procedure.
‡Defined as any person who received a non-elective AVR (not including due to emergent or urgent conditions such as endocarditis or aortic dissections), OR a non-elective admission to hospital due to aortic valve disease or congestive HF, in the 12 months prior to their index procedure
§People who do not fit into either defined pathway.
AVR, aortic valve replacement; CPRD, Clinical Practice Research Datalink; HES, Hospital Episode Statistics.

Table 4 Proportion of people receiving timely AVR, delayed AVR or AVR via a different pathway for each deprivation (IMD) quintile for the CPRD-HES cohort

	CPRD Index of Multiple Deprivation (IMD)					
	IMD quintile 1 (most deprived)	**IMD quintile 2**	**IMD quintile 3**	**IMD quintile 4**	**IMD quintile 5 (0.81–1.00)** (least deprived)	**IMD quintile unknown**
Total*, n	1429	1799	2085	2239	2489	28
Timely AVR†, n (%)	830 (58.08%)	1152 (64.04%)	1377 (66.04%)	1460 (65.21%)	1692 (67.98%)	20 (71.43%)
Delayed AVR‡, n (%)	472 (33.03%)	516 (28.68%)	577 (27.67%)	645 (28.81%)	656 (26.36%)	**S**
Other AVR §, n (%)	127 (8.89%)	131 (7.28%)	131 (6.28%)	134 (5.98%)	141 (5.66%)	**S**

S denotes cells suppressed due to small patient numbers (<5) to prevent identification of patients, as required by CPRD.
All three pathways are mutually exclusive.
*The total number of people in each respective group, used as the denominator for the stated percentages from the CPRD-HES AVR cohort.
†Defined as any person who has undergone an elective AVR, AND who does not have a non-elective admission to hospital due to aortic valve disease or congestive heart failure (HF), in the 12 months prior to their index procedure, AND has a record of an outpatient appointment within the cardiology or cardiac surgery treatment specialties, and/or a record of an echocardiogram prior to their index procedure.
‡Defined as any person who received a non-elective AVR (not including due to emergent or urgent conditions such as endocarditis or aortic dissections), OR a non-elective admission to hospital due to aortic valve disease or congestive HF, in the 12 months prior to their index procedure.
§People who do not fit into either defined pathway.
AVR, aortic valve replacement; CPRD, Clinical Practice Research Datalink; HES, Hospital Episode Statistics; IMD, Index of Multiple Deprivation.

AS and AVR datasets used have national coverage for diagnoses and procedures in secondary care, thus these results are generalisable to the UK and countries with similar healthcare systems and demographics. The linked CPRD-HES dataset is representative of age, sex, ethnicity and socioeconomic status, and contains information on management in the community, providing a more holistic picture of the pathway to AVR for a subset of people.[20 21]

Our results on gender disparity in access to AVR agree with the literature showing that, despite similar incidence and severity of AS, women are less often referred for AVR than men.[6 22 23] This has been reported in several countries, including the USA and France.[22 24] In a prospective study of 3632 with AS (42% of them women) women were less likely to be referred for valve intervention (p=0.007) and more likely to die than men (p=0.01). Tribouilloy *et al* demonstrated higher 5-year mortality among women than men (79% vs 70%; p<0.001), and longer waits for AVR among women (16 vs 14 months, p=0.005).[22] Women tended to be older (p<0.001) and were more likely to have symptoms than men (p=0.007). Tribouilloy *et al* concluded that women might be managed conservatively (without AVR intervention) longer and undergo AVR less frequently, despite experiencing more symptoms which is consistent with our findings.[22]

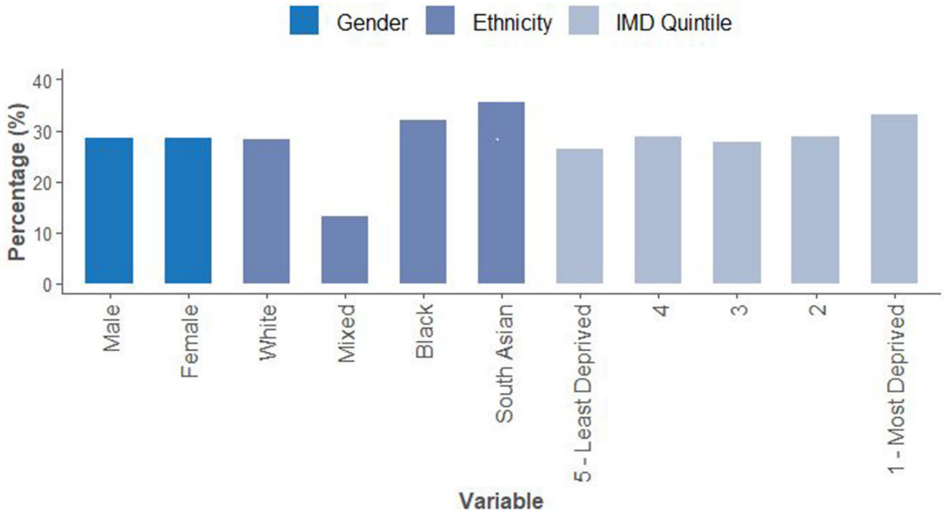

Figure 3 Proportion of people receiving delayed AVR (non-elective AVR and/or evidence of cardiac decompensation prior to AVR). AVR, aortic valve replacement; IMD, Index of Multiple Deprivation.

Table 5 Timing of delayed pathway to AVR by gender

	Gender	
	Male	Female
Time* from first secondary care cardiovascular touchpoint to AVR (days); median (IQR)	1383 (3296.5)	1476 (3100)
Primary care consultations in the 24 months before AVR; median (IQR)	34 (58)	41 (67)

*Defined as the period between first outpatient cardiology, cardiac surgery, or cardiothoracic surgery appointment, or record of an echocardiogram to index AVR for those with known AS (any severity, severe symptomatic AS).
AS, aortic stenosis; AVR, aortic valve replacement.

Similar findings were obtained in North America, where Chaker *et al* found significantly increased in-hospital mortality among women with isolated AVR compared with propensity score matched men (3.3% vs 2.9%, p<0.001).[25] Hahn *et al* highlighted numerous differences between the management of men and women with AS, including disparities in the assessment of severity, haemodynamic status and timing of intervention.[6] In particular, they showed that women are less frequently referred for intervention after a diagnosis of significant AS than men.

A placebo-controlled, double-blind, randomised prospective study did not identify any sex differences in progression of AS that would explain gender imbalance in AVR provision, however, the median follow-up of 4 years is insufficient to rule out sex differences later in the natural history of the disease that may impact AVR provision.[23] Similarly, a systematic review of treatment disparities in AS found that there is insufficient research to determine 'whether minorities are prone to have disease-related factors that bias against AVR'. Thus, more research is required to determine whether other gender or ethnicity-based factors are barriers to AVR, in order to ensure this life-saving treatment is available to all those who would benefit.

Blair *et al* proposed that unconscious bias in the healthcare system and among healthcare professionals such as a 'male as default' approach, may contribute to biases in healthcare provision for women.[26] Together with our study results, these data further support the rationale for greater physician and patient awareness about gender differences in valvular disease pathology and presentation. Gender disparities in care are coming under increased scrutiny, for example, the UK government's ten-year strategy published in Women's Health Strategy for England,[7] which commits to identifying and changing systemic factors to close the gender health gap. Gender-specific research is needed to inform such a strategy to understand how disparities influence clinical practice. Furthermore, it is important to elucidate how the National Health Service (NHS) in England can better recognise an unconscious 'male default' perspective in the healthcare system, which might undermine the care of women.[7]

Our study provides an estimate of ethnicity-based disparity in provision of AVR in England. We found that the odds of a person of black ethnicity receiving an AVR were significantly lower than a person of white ethnicity. In a similar study from Minnesota, Alqahtani *et al* analysed data from 96 278 people, >60 years old, hospitalised with a primary diagnosis of AS and found that the ratio of AVR to AS-related admissions was significantly lower for people of black (4.7%) than white (11.3%, p<0.001) ethnicities.[9] Matthew Brennan *et al*[8] conducted a retrospective study on 32 853 people with new symptomatic severe AS between 2011 and 2016 using US eMRs.[8] They observed that those from a black ethnic background were less likely than people from a white ethnic background to receive an AVR at 1-year postsymptomatic severe AS diagnosis (23% vs 31%; adjusted HR 0.76; 95% CI 0.67 to 0.85).[8] In this study, we also report a lower odds of AVR for people of South Asian ethnicities who form a larger proportion (9%) of the English population than the USA (2%) as calculated from US census population data.[27] To our knowledge, there is no literature specifically addressing health disparities for people of South Asian ethnicity with AS in the USA or UK.

We also report differences in the care pathway to AVR for people of different ethnicities CPRD-AVR cohort. Notably, our analysis showed that a higher proportion of people of black and South Asian ethnicities had delayed AVR than people of white ethnicities in England. In a large, retrospective, cohort study from the USA, a higher proportion of people of black ethnicities compared with white had an urgent or emergent AVR (25.82% compared with 17.29%)[28] which correlates with our findings.

According to the 2021 England and Wales ethnicity census, the population of England consists of people who identify their ethnicity as white (82%), South Asian (9%), black (4%), any mixed ethnicity (3%) or other, including Chinese and Arab (3%).[18] Generally, all minority ethnicities were under-represented in our AS and AVR cohorts when compared with the 2021 census. People of South Asian ethnicity comprise just 2.6% of the AS cohort and 4.4% of the AVR cohort. These proportions are 0.91% and 0.80% for people of black ethnicity. The apparent under-representation of people of black and South Asian ethnicity in our cohorts compared with the English population may be due to the populations of these ethnicities generally being younger than the population of white ethnicity. Our ORs were age-adjusted and should have accounted for this, meaning it is unlikely that the reduced proportions of minority ethnicity populations identified led to estimation of a lower OR.

Recently, a unique large population-based study of valvular heart disease in England, the OxVALVE population cohort study, attempted to quantify undiagnosed valvular heart disease. However, 99% of study participants were of white ethnicities, which was not representative of the different ethnic populations in England.[16] Similar population studies with better inclusion of underrepresented ethnic groups are needed to understand how discrepancies in management of AS and provision of AVR can be addressed, including further research on the underlying causes of ethnic disparity in the provision of AVR in all countries, including the UK.

The most deprived people were underrepresented in the HES-AS, HES-AVR and CPRD-HES cohorts (17%, 14% and 14%, respectively). IMD is a distributional measure, and all things being equal, one would expect 20% of people with AS to be represented in each IMD quintile in our study. Our findings align with those of the OxVALVE study, which showed a higher prevalence of undiagnosed valvular heart disease among those in the most deprived IMD quintiles than the least deprived.[16] In addition, we found that among a cohort of people with diagnosed AS, the most socioeconomically deprived were less likely to receive AVR than the least deprived. Moreover, delayed AVR was more common in the most deprived compared with the least deprived people with AS.

Strengths and limitations

HES is a national dataset for England, provided for research as secondary use statistics. As such it is representative of all NHS-funded secondary care and a good data source for studying inequities. The quality of the data received is subject to coding practices within the English NHS. The completeness of the data is as we received it; we did not apply any imputation or correction of the data.

The main objective was to compare receipt of AVR in men and women; the HES-AS cohort, identified from IP diagnoses, is gender balanced (48% women). However, we cannot determine from these cohorts whether there is a gender bias in the diagnosis of AS when we include diagnoses in primary care. However, the proportion of women who had received an AVR (37%) was the same in the hospital cohort (HES-AVR) as in the primary care CPRD-HES cohorts.

It should be noted that gender and ethnicity are nominally self-defined in both HES and CPRD-HES datasets. Gender data is >99% complete across all three cohorts and notably, where primary and secondary care records were linked, or when people were followed longitudinally, gender and ethnicity remained consistent. Ethnicity is generally well recorded in both HES and CPRD, particularly after 2006 when Quality Outcome Framework incentives were introduced to improve recording in primary care. In 2013, it was estimated that 78% of CPRD patients registered after 2006 had usable (excluding unknown or not stated) ethnicity data and 86% of HES patients had usable data, giving 97.1% combined usable data.[29] We acknowledge that there is a lower proportion (81%) of patients with usable ethnicity data within the HES-AVR cohort compared with HES in general (86%) as well as the HES-AS (92%) and CPRD-HES (99%) cohorts, and this may potentially bias our results if recording of usable ethnicity is low in certain ethnic groups.

A recent ONS report[30] shows that the agreement rate between the 2011 census and HES data up to 2021 is approximately 76% for people of black African and black Caribbean ethnicities, 88% for people of South Asian ethnicities, and though there is 97% agreement for people of white ethnicities, they make up the vast majority (85%—calculated from Office for National Statistics (ONS) dataset) of all those with unknown or not stated ethnicities. This suggests that there may be a small amount of recording bias across HES data which could affect the certainty around our OR estimates, particularly for those of mixed ethnicity where agreement is less than 67%[30] and CIs around the OR are wide.

Although our study highlights differences in the odds of receiving AVR and the timeliness of care, it cannot identify barriers to access or provision of care. This paper addresses the unidimensional differences in healthcare received by gender, ethnicity and social deprivation. To determine how best to address unmet needs among the most underserved groups, it is imperative to consider intersectional differences in provision of AVR. Our study identified a baseline cohort of people diagnosed with AS and therefore did not consider the burden of undiagnosed AS, which would potentially amplify any disparities. Furthermore, the data analysed in our study looked at the aggregated provision of AVR (SAVR and TAVI) and did not consider procedural or outcome differences based on gender, ethnicity and social deprivation.

Future solutions/research

Further research on each of these aspects will be important; however, intersectional research looking at the interaction of health disparities when gender, ethnicity and deprivation are combined will be crucial. Segment-specific solutions may need to address health discrepancies for each of gender, ethnicity and deprivation; however, these should be informed by intersectional analysis. We suggest that where there is evidence of good practice and positive interventions addressing disparities, there should be a process of validation by replication and knowledge-sharing across hospitals, regions and nationally. While OxVALVE was commendable in quantifying the burden of undiagnosed valvular heart disease, similar population studies with better inclusion of underrepresented ethnic groups are needed to understand how discrepancies in management of AS and provision of AVR can be addressed.

CONCLUSIONS

This is the first study to analyse the differences in provision of, and care pathway to, AVR for people with AS in

England by gender, ethnicity and level of social deprivation. Differences based on gender, ethnicity and deprivation level were identified; women, people of minority ethnicities and greater deprivation had lower odds of receiving AVR compared with men, people of white ethnicity and least deprived, respectively. Where these groups did receive an AVR, a higher proportion had a non-elective procedure or experienced cardiac decompensation on or before their procedure date. Further research is needed to investigate the reasons for under provision of AVR in certain person groups and to identify whether disparity is related to structural or systemic inequities, genetic inequalities or differences in patient behaviours or preferences.

Twitter Caoimhe T Rice @drctrice and Benoy N Shah @dr_benoy_n_shah

Acknowledgements We are grateful for the contributions of the following: John Were and Rebeka McClintock participated in the initial study concept. Archie Farmer and Mico Hamlin helped with the dataset analysis. Klara Belzar, PhD and Prescript Communications, Letchworth, UK, provided medical writing and editorial assistance in preparing this manuscript.

Contributors CTR contributed to the interpretation of data, drafting and critical revision of the manuscript, and is the guarantor of the study. SPO'C contributed to the design of the work, oversaw the statistical analysis and critical appraisal of the manuscript. SB contributed to the initial concept and design of the work as well as critically appraising the manuscript. EA, CEA, JBC, BNS and DJB all contributed to the clinical interpretation of the data as well as critical appraisal of the manuscript.

Funding The funding for this study was provided by Medtronic.

Competing interests CTR and SPO'C were employed by CorEvitas (Specialty EMR Data division), which was funded by Medtronic to conduct this research. SB is an employee of Medtronic. DJB is a consultant and proctor for Medtronic. CEA has received honoraria from Medtronic. The remaining authors have no conflict of interest to declare.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. This study used third party data made available under licence that the authors do not have permission to share. Requests to access the data should be directed to NHS digital at enquiries@nhsdigital.nhs.uk for HES data and CPRD at enquiries@cprd.com for CPRD-HES linked data.

ORCID iDs
Caoimhe T Rice http://orcid.org/0000-0003-3017-2279
Sophie Barnett http://orcid.org/0009-0001-5362-172X
Enoch Akowuah http://orcid.org/0000-0002-2429-3579
John B Chambers http://orcid.org/0000-0002-7169-3786
Benoy N Shah http://orcid.org/0000-0001-9681-7311

REFERENCES

1 Vahanian A, Beyersdorf F, Praz F. ESC/EACTS guidelines for the management of valvular heart disease: developed by the task force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic surgery (EACTS). *Eur Heart J* 2022;43:561–632.
2 Kitai T, Honda S, Okada Y, *et al*. Clinical outcomes in non-surgically managed patients with very severe versus severe aortic stenosis. *Heart* 2011;97:2029–32.
3 National Institute for Health and Care Excellence (NICE). Heart valve disease presenting in adults: investigation and management. NICE guideline NG208. 2021. Available: https://www.nice.org.uk/guidance/ng208/resources/heart-valve-disease-presenting-in-adults-investigation-and-management-pdf-66143721453253 [Accessed 1 Sep 2022].
4 Otto CM, Nishimura RA, Bonow RO, *et al*. ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on clinical practice guidelines. *Circulation* 2021;143:e72–227.
5 Ali N, Faour A, Rawlins J, *et al*. Valve for life': tackling the deficit in transcatheter treatment of heart valve disease in the UK. *Open Heart* 2021;8:e001547.
6 Hahn RT, Clavel M-A, Mascherbauer J, *et al*. Sex-related factors in valvular heart disease. *J Am Coll Cardiol* 2022;79:1506–18.
7 UK Health and Social Care. Women's health strategy for England 2022. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1100706/Womens-Health-Strategy-England-print.pdf] [Accessed 1 Sep 2022].
8 Matthew Brennan J, Leon MB, Sheridan P, *et al*. Racial differences in the use of aortic valve replacement for treatment of symptomatic severe aortic valve stenosis in the transcatheter aortic valve replacement era. *J Am Heart Assoc* 2020;9:e015879.
9 Alqahtani F, Aljohani S, Amin AH, *et al*. Effect of race on the incidence of aortic stenosis and outcomes of aortic valve replacement in the United States. *Mayo Clin Proc* 2018;93:607–17.
10 Bob-Manuel T, Sharma A, Nanda A, *et al*. A review of racial disparities in Transcatheter aortic valve replacement (TAVR): accessibility, referrals and implantation. *Ann Transl Med* 2018;6:10.
11 Wilson JB, Jackson LR, Ugowe FE, *et al*. Racial and ethnic differences in treatment and outcomes of severe aortic stenosis. *JACC Cardiovasc Interv* 2020;13:149–56.
12 Office of National Statistics. Health state life Expectancies by National deprivation Deciles England 2018 to 2020. 2021. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthinequalities/bulletins/healthstatelifeexpectanciesbyindexofmultipledeprivationimd/2018to2020 [Accessed Oct 2022]
13 GOV.UK. Guidance: place-based approaches for reducing health inequalities: main report. Available: https://www.gov.uk/government/publications/health-inequalities-place-based-approaches-to-reduce-inequalities/place-based-approaches-for-reducing-health-inequalities-main-report#fn:11 [Accessed Oct 2022]
14 Empana JP, Perier MC, Singh-Manoux A, *et al*. Cross-sectional analysis of deprivation and ideal cardiovascular health in the Paris prospective study 3. *Heart* 2016;102:1890–7.
15 Romeri E, Baker A, Griffiths C. Mortality by deprivation and cause of death in England and Wales, 1999-2003. *Health Stat Q* 2006:19–34.
16 d'Arcy JL, Coffey S, Loudon MA, *et al*. Large-scale community echocardiographic screening reveals a major burden of undiagnosed valvular heart disease in older people: the Oxvalve population cohort study. *Eur Heart J* 2016;37:3515–22.
17 Kerry-Barnard S, Gomes D. *National Child Development Study: a guide to the linked health administrative datasets – Hospital Episode Statistics (HES)*. London: UCL Centre for Longitudinal Studies, 2020.
18 GOV.UK. Ethnicity facts and figures. Available: https://www.ethnicity-facts-figures.service.gov.uk/style-guide/ethnic-groups] [Accessed 6 Apr 2023].
19 McLennan D, Noble S, Noble M, *et al*. The English indices of deprivation 2019 technical report. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833951/IoD2019_Technical_Report.pdf [Accessed Sep 2022]
20 Herrett E, Gallagher AM, Bhaskaran K, *et al*. Data resource profile: clinical practice research datalink (CPRD). *Int J Epidemiol* 2015;44:827–36.
21 Mahadevan P, Harley M, Fordyce S, *et al*. Completeness and Representativeness of small area socioeconomic data linked with the UK clinical practice research Datalink (CPRD). *J Epidemiol Community Health* 2022;76:880–6.
22 Tribouilloy C, Bohbot Y, Rusinaru D, *et al*. Excess mortality and undertreatment of women with severe aortic stenosis. *J Am Heart Assoc* 2021;10:e018816.
23 Cramariuc D, Rogge BP, Lønnebakken MT, *et al*. Sex differences in cardiovascular outcome during progression of aortic valve stenosis. *Heart* 2015;101:209–14.
24 Lowenstern A, Sheridan P, Wang TY, *et al*. Sex disparities in patients with symptomatic severe aortic stenosis. *Am Heart J* 2021;237:116–26.

25 Chaker Z, Badhwar V, Alqahtani F, *et al*. Sex differences in the utilization and outcomes of surgical aortic valve replacement for severe aortic stenosis. *J Am Heart Assoc* 2017;6:e006370.
26 Blair IV, Steiner JF, Havranek EP. Unconscious (implicit) bias and health disparities: where do we go from here? *TPJ* 2011;15:71–8.
27 Bureau USC. Decennial census 2020. Available: https://data.census.gov/table?g=010XX00US&tid=DECENNIALPL2020.P1 [Accessed 6 Apr 2023].
28 Taylor NE, O'Brien S, Edwards FH, *et al*. Relationship between race and mortality and morbidity after valve replacement surgery. *Circulation* 2005;111:1305–12.
29 Mathur R, Bhaskaran K, Chaturvedi N, *et al*. Completeness and usability of Ethnicity data in UK-based primary care and hospital databases. *J Public Health (Oxf)* 2014;36:684–92.
30 Office for National Statistics (ONS). Understanding consistency of ethnicity data recorded in health-related administrative datasets in England: 2011 to 2021. 2021. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthinequalities/articles/understandingconsistencyofethnicitydatarecordedinhealthrelatedadministrativedatasetsinengland2011to2021/2023-01-16 [Accessed 6 Apr 2023].