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Association of socioeconomic status with clinical characteristics, care quality and outcomes in patients undergoing transcatheter aortic valve implantation☆

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A R T I C L E I N F O

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A B S T R A C T

Background: Socioeconomic status (SES) is an important determinant of healthcare outcomes in many settings, but few studies have evaluated the impact of SES among patients with aortic stenosis (AS). We sought to explore the association between SES and clinical characteristics, care quality and outcomes among patients undergoing transcatheter aortic valve implantation (TAVI) for severe AS.
Methods: Consecutive patients undergoing TAVI for severe AS at three hospitals between August 2008 and February 2023 were prospectively enrolled in a multicentre registry. Patients were stratified into SES quintiles using a census-derived index. Demographic, procedural, and outcomes data were retrospectively analysed.
Results: A total of 2,462 patients underwent TAVI during the study period. Lower SES patients were younger than those of higher SES, had more comorbidities, and were less likely to have private health insurance or receive care in private hospitals. Compared to higher SES groups, lower SES patients presented with more advanced disease markers (lower aortic valve area, lower dimensionless index, increased pulmonary hypertension) and were more likely to undergo urgent TAVI, but faced longer wait times for elective TAVI. Despite these pre-procedural differences, mortality and complication rates were similar across SES groups. In multivariable analyses, SES was not an independent predictor of mortality or major adverse cardiovascular events (MACE) at 30 days or 12 months.
Conclusions: SES did not independently predict mortality or MACE in patients undergoing TAVI for severe AS. However, disparities in pre-procedural characteristics and access barriers were identified, highlighting the need to address SES-related inequities in healthcare delivery.

1. Introduction

Aortic stenosis (AS) is the most prevalent valvular heart disease in developed countries and is associated with substantial morbidity and mortality. Without treatment, symptomatic severe AS has a two-year mortality rate of around 50 % [1]. Currently, the only effective treatment for AS is aortic valve replacement through either surgical aortic valve replacement (SAVR) or transcatheter aortic valve implantation (TAVI). TAVI in particular has revolutionised the landscape of AS management, providing a life-saving option for patients once considered to be at unacceptably high surgical risk. Increasing evidence for the safety and efficacy of TAVI has further expanded its indications, and it is now a well-established alternative to SAVR among low- and intermediate-risk patients [2,3].

Timely and equitable access to TAVI is critical given strong evidence that symptom onset in AS heralds the rapid development of major

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adverse cardiovascular events and death [1]. Socioeconomic status (SES) is a known determinant of healthcare access and outcomes, [4,5] but few studies have specifically evaluated its impact among patients undergoing TAVI. The relationship between SES and TAVI is of particular interest due to the specialised and high-cost nature of the TAVI procedure [6,7]. The tendency for TAVI services to be concentrated within high-volume metropolitan centres, coupled with the need for multidisciplinary expertise and specialised pre-procedural assessments, further underscores the potential for disparities in care [4].

In this study, we aimed to evaluate the relationship between SES and patient characteristics, care quality, and clinical outcomes among patients undergoing TAVI for severe AS in Australia, a country with universal healthcare.

2. Methods

This was a retrospective cohort study of consecutive patients undergoing TAVI for severe AS between August 2008 and February 2023 across three centres in Melbourne, Australia. Informed consent was obtained from all study participants and the study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval from the Alfred Hospital Ethics Committee (ID 176/24).

2.1. Study setting

Australia's healthcare system is underpinned by a universal health insurance scheme known as Medicare. Through Medicare, Australians are guaranteed access to fee-free treatment within public hospitals and can access a range of subsidised outpatient services including specialist care, imaging and pathology, and some medications [8]. Private health insurance is available for those who wish to choose their own clinician and for some nonsubsidised services such as dental or optical care [8]. Patients with private insurance may also have faster access to some investigations and procedures. However, overall quality of care is expected to be equivalent between public and private sectors [9].

2.2. Data sources

Data for this study were obtained from the Alfred Cabrini Epworth (ACE) TAVI registry, a clinical registry that prospectively collects patient demographics, procedural details, and follow up information for all patients undergoing TAVI at three participating hospitals in Melbourne, Australia. Details regarding the registry have been previously published [9–11]. The registry includes one quaternary public hospital performing > 200 TAVI procedures annually and two large private hospitals each performing > 100 TAVI procedures annually. Data are collected at baseline, 30 days, 12 months, and yearly post-TAVI, and are routinely submitted to the National Australasian Cardiac Outcomes Registry database, which is governed by the Cardiac Society of Australia and New Zealand and undergoes regular audit [12].

2.3. Study population and definitions

Adult patients (≥18 years) included in the ACE registry who underwent TAVI for severe AS between August 2008 and February 2023 were included. Severe AS was defined as an aortic valve area < 1.0 cm^2 and/or a mean pressure gradient across the aortic valve > 40 mmHg [13]. Patients were deemed suitable for TAVI based on consensus by the local multidisciplinary heart team. We excluded those who underwent TAVI for non-AS indications or if residential postcode data were unavailable to allow for derivation of SES.

SES was determined using the Index of Relative Socioeconomic Disadvantage (ISRD) score, a measure developed by the Australian Bureau of Statistics using national census data [14]. Scores are derived for each residential postcode based on a weighted combination of factors including household income, unemployment rate, home and motor vehicle ownership, educational level, and non-English speaking background. The IRSD score is then converted into percentiles. Consistent with other studies, we divided the IRSD data into quintiles as follows: highest (percentiles 81–100), high (percentiles 61–80), middle (percentiles 41–60), low (percentiles 21–40), and lowest (percentiles 1–20) [15,16].

2.4. Outcomes

The primary outcome was 30-day mortality stratified by SES quintile. Secondary outcomes included major adverse cardiovascular events (MACE, defined as a composite of all-cause mortality, stroke, myocardial infarction, or heart failure rehospitalisation) at 30-days and 12-months, 12-month all-cause mortality, individual complications according to Valve Academic Research Consortium-3 (VARC-3) definitions at 30-days and 12-months (including myocardial infarction, stroke, major bleeding, major vascular complications, and permanent pacemaker insertion), and hospital length of stay [17].

Quality of care metrics included workup wait time (period of time between the initial referral for assessment to completion of all pre-operative investigations and approval for TAVI at a multidisciplinary heart team meeting), procedure wait time (period of time between approval for TAVI and procedure date), and total wait time (sum of workup wait time and procedural wait time). Treatment in the recommended time was defined as a procedure wait time that fell within the assigned urgency category (i.e. less than 30 days for patients assigned an urgency category 1, 60 days for patients assigned an urgency category "high 2", and 90 days for patients assigned an urgency category 2).

2.5. Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range). Categorical variables are presented as frequencies and percentages. *P*-values for trends across SES groups were calculated using the Cochran-Armitage test for binary variables and the Jonckheere-Terpstra test for non-binary categorical and continuous variables. To evaluate whether SES is an independent predictor of outcomes, multivariable logistic regression analyses were conducted for 30-day mortality, 30-day MACE, 12-month mortality, and 12-month MACE. Covariates in the multivariable analyses included age, sex, hypertension, diabetes, atrial fibrillation/flutter, stroke, coronary artery disease, peripheral vascular disease, eGFR < 30 mL/min/1.73 m^2, Society of Thoracic Surgeons (STS) risk score, aortic valve area (AVA), aortic valve mean pressure gradient (MPG), and left ventricular ejection fraction (LVEF) < 50 %. Results are reported as adjusted odds ratio (aOR) and corresponding 95 % CI. For multivariable analyses, missing comorbidity data were assumed to represent the absence of the comorbidity. Complete case analysis was used for other covariates. Analyses were performed using StataMP version 18.0 (StataCorp, College Station, TX). Two-sided p-values < 0.05 were considered statistically significant.

3. Results

A total of 2,589 patients underwent TAVI for severe AS between August 2008 and February 2023. Of these, 127 did not have postal code data and were excluded, leaving 2,462 patients in the final analysis. There was an uneven distribution of patients across SES quintiles, with 353 (14.3 %) patients in SES quintile 1 (lowest quintile), 338 (13.7 %) patients in quintile 2, 391 (15.9 %) patients in quintile 3, 465 (18.9 %) patients in SES quintile 4, and 915 (37.2 %) patients in quintile 5 (highest quintile) **(**Fig. 1**).**

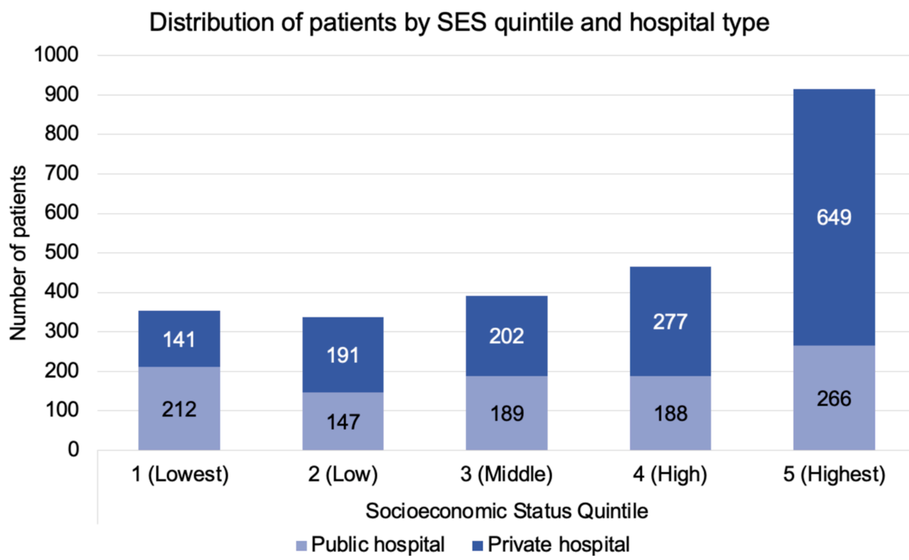

Fig. 1. Distribution of TAVI Patients by Socioeconomic Status (SES) Quintile and Hospital Type. The distribution of patients undergoing TAVI in the ACE registry, stratified by SES quintile and categorised by the type of hospital (private or public), is presented. The data reveal a disproportionate concentration of patients from the highest SES quintile, particularly in private hospital settings, highlighting an SES gradient in healthcare access within the context of universal health coverage. TAVI indicates transcatheter aortic valve implantation.

Table 1
Baseline Characteristics.

Variable	Socioeconomic Status Quintile					P trend
	1 (Lowest)	2 (Low)	3 (Middle)	4 (High)	5 (Highest)	
Number of patients	353 (14.3 %)	338 (13.7 %)	391 (15.9 %)	465 (18.9 %)	915 (37.2 %)	
Age, years	81.3 ± 6.6	81.6 ± 7.2	80.7 ± 8.1	82.0 ± 6.3	82.5 ± 6.7	<0.001
Male sex, no (%)	205 (58.1 %)	203 (60.1 %)	219 (56.2 %)	247 (53.1 %)	521 (57.0 %)	0.49
Caucasian ethnicity	251 (98.1 %)	241 (96.0 %)	316 (97.5 %)	345 (96.4 %)	642 (95.8 %)	0.14
Transfemoral TAVI	340 (96.3 %)	330 (97.6 %)	387 (99.0 %)	453 (97.4 %)	895 (97.9 %)	0.41
Balloon-expandable valve	127 (36.1 %)	100 (29.7 %)	138 (35.5 %)	134 (29.1 %)	303 (33.2 %)	0.07
Private hospital	141 (39.9 %)	191 (56.5 %)	202 (51.7 %	277 (59.6 %)	649 (70.9 %)	<0.001
Private health insurance	148 (41.9 %)	198 (58.6 %)	204 (52.2 %)	574 (63.0 %)	674 (73.7 %)	<0.001
Body mass index, kg/m^2	28.9 ± 6.0	28.0 ± 5.4	28.9 ± 5.7	27.9 ± 5.5	27.2 ± 5.1	<0.001
BMI > 30 kg/m^2, no (%)	131 (39.0 %)	98 (31.2 %)	141 (37.4 %)	136 (32.1 %)	201 (24.7 %)	<0.001
STS risk score	3.7 (2.3 – 5.9)	3.5 (2.2 – 5.1)	3.4 (2.1 – 5.4)	3.7 (2.4 – 5.7)	3.9 (2.5 – 5.5)	0.06
Coronary artery disease, n(%)	241 (68.3 %)	226 (67.1 %)	289 (74.3 %)	305 (65.9 %)	612 (67.0 %)	0.40
Previous MI, n(%)	62 (18.7 %)	42 (13.3 %)	60 (16.0 %)	63 (14.9 %)	96 (11.8 %)	0.009
Previous PCI, n(%)	92 (26.1 %)	100 (29.8 %)	104 (26.7 %)	114 (24.6 %)	221 (24.2 %)	0.11
Previous CABG, n(%)	51 (14.5 %)	50 (14.8 %)	57 (14.6 %)	72 (15.6 %)	124 (13.6 %)	0.65
Previous stroke, n(%)	34 (9.6 %)	34 (10.1 %)	35 (9.0 %)	52 (11.2 %)	79 (8.7 %)	0.62
PVD, n(%)	45 (12.8 %)	52 (15.6 %)	56 (14.4 %)	66 (14.4 %)	123 (13.7 %)	0.97
Diabetes, n(%)	119 (33.7 %)	92 (27.3 %)	137 (35.1 %)	132 (28.5 %)	204 (22.4 %)	<0.001
Hypertension, n(%)	279 (79.0 %)	260 (77.2 %)	316 (81.0 %)	368 (79.3 %)	700 (76.7 %)	0.38
Atrial fibrillation or flutter, n(%)	114 (32.3 %)	110 (32.5 %)	126 (32.4 %)	159 (34.3 %)	283 (31.0 %)	0.68
Prior PPM or ICD, n(%)	42 (11.9 %)	50 (14.8 %)	48 (12.3 %)	59 (12.7 %)	143 (15.7 %)	0.13
Prior heart failure, n(%)	184 (60.1 %)	157 (52.3 %)	186 (52.4 %)	200 (50.1 %)	351 (45.6 %)	<0.001
eGFR < 30, n(%)	21 (6.5 %)	20 (6.3 %)	19 (5.2 %)	28 (6.4 %)	51 (6.0 %)	0.86
Dialysis, n(%)	6 (1.8 %)	5 (1.6 %)	4 (1.1 %)	10 (2.3 %)	19 (2.3 %)	0.29
Moderate + lung disease, n(%)	35 (10.2 %)	28 (8.6 %)	51 (13.2 %)	43 (9.6 %)	101 (11.4 %)	0.45
Residential care, n(%)	8 (2.4 %)	8 (2.5 %)	14 (3.7 %)	16 (3.6 %)	48 (5.5 %)	0.84
NYHA III or IV, no (%)	170 (49.6 %)	159 (49.1 %)	228 (50.0 %)	228 (50.0 %)	480 (54.1 %)	0.07
AVA, cm^2	0.77 ± 0.19	0.79 ± 0.36	0.83 ± 0.32	0.81 ± 0.38	0.79 ± 0.23	0.24
AVAi, cm^2/m^2	0.42 ± 0.10	0.43 ± 0.18	0.45 ± 0.17	0.45 ± 0.20	0.44 ± 0.13	0.02
MPG, mmHg	45.3 ± 13.4	46.0 ± 12.9	44.4 ± 12.4	45.1 ± 12.2	45.2 ± 12.7	0.64
Aortic valve DI	0.21 ± 0.06	0.22 ± 0.05	0.23 ± 0.08	0.23 ± 0.06	0.23 ± 0.08	0.003
LVEF (%)	56.8 ± 11.7	58.3 ± 11.2	57.9 ± 11.2	58.9 ± 10.6	58.1 ± 10.6	0.69
RVSP, mmHg	40.4 ± 14.3	38.1 ± 13.0	36.8 ± 11.9	38.7 ± 12.2	36.6 ± 12.6	<0.001
RVSP > 40 mmHg, n(%)	96 (44.9 %)	78 (38.2 %)	72 (33.3 %)	117 (39.8 %)	213 (33.0 %)	0.007
Moderate or severe AR, n(%)	32 (9.3 %)	47 (14.3 %)	41 (11.0 %)	43 (9.5 %)	98 (11.1 %)	0.83
Moderate or severe MR, n(%)	36 (10.8 %)	38 (11.9 %)	51 (13.8 %)	53 (11.9 %)	107 (12.2 %)	0.71
Previous BAV	58 (16.6 %)	38 (11.3 %)	44 (11.3 %)	56 (12.3 %)	104 (11.5 %)	0.09

AR indicates aortic regurgitation; AVA, aortic valve area; AVAi, indexed aortic valve area; BAV, balloon aortic valvuloplasty; BMI, body mass index; CABG, coronary artery bypass graft; DI, dimensionless index; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MPG, mean pressure gradient; MR, mitral regurgitation; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; PPM, permanent pacemaker; PVD, peripheral vascular disease; RVSP, right ventricular systolic pressure; STS, Society of Thoracic Surgeons; and TAVI, transcatheter aortic valve implantation.

3.1. Baseline characteristics

The mean age of patients was 81.8 ± 7.0 years and 56.7 % were male. Lower SES patients were younger than those in higher SES quintiles (mean age 81.3 ± 6.6 years in lowest quintile versus 82.5 ± 6.7 years in highest quintile, p-trend < 0.001), whereas sex distribution was similar across groups (Table 1). Overall, 40.7 % of procedures occurred in the public hospital setting and 59.3 % in private hospitals. Higher SES patients were more likely to receive care in private hospitals (39.9 % in lowest quintile versus 70.9 % in highest quintile, p-trend < 0.001) and had higher rates of private health insurance (41.9 % in lowest quintile versus 73.7 % in highest quintile, p-trend < 0.001).

Lower SES was associated with higher rates of obesity, diabetes, and a history of myocardial infarction or heart failure. Other comorbidities were similarly distributed across SES groups. Lower SES groups had a lower mean indexed AVA (0.42 ± 0.10 cm^2/m^2 in lowest quintile versus 0.44 ± 0.13 cm^2/m^2 in highest quintile, p-trend = 0.02) and aortic valve dimensionless index (0.21 ± 0.06 in lowest quintile versus 0.23 ± 0.08 in highest quintile, p-trend = 0.007), and a slightly higher LV mass index (109 ± 30 in lowest quintile versus 107 ± 30 in highest quintile, p-trend = 0.02) compared to higher SES groups, but baseline aortic valve MPG and LVEF were similar. Additionally, patients in lower SES quintiles had a higher mean right ventricular systolic pressure (RVSP, 40.4 ± 14.3 mmHg in the lowest quintile versus 36.6 ± 12.6 mmHg in highest quintile, p-trend < 0.001) and an increased prevalence of pulmonary hypertension (RVSP > 40 mmHg) at baseline (44.9 % in the lowest quintile versus 33.0 % in the highest quintile, p-trend = 0.007).

3.2. Procedural and quality-of-care metrics

The majority of patients (97.2 %) in the cohort underwent transfemoral TAVI, with no significant variation in the primary access site observed across SES groups. Balloon-expandable valves were deployed in 32.7 % of cases, without significant differences in valve type between SES quintiles.

Patients in lower SES groups were more likely to undergo TAVI as an urgent inpatient procedure compared to those in higher SES groups (12.6 % in the lowest quintile versus 7.8 % in the highest quintile, p-trend = 0.02). In contrast, for elective TAVI procedures, lower SES groups were less often assigned the highest urgency category (35.0 % assigned "Category 1" in lowest quintile versus 56.4 % in highest quintile, p-trend = 0.02) (Table 2).

Excluding urgent inpatient cases, lower SES patients faced longer workup times (62 [33 – 105] days in lowest quintile versus 48 [18–90] days in highest quintile, p-trend = 0.008) and longer procedure wait times (37 [14 – 67] days in lowest quintile versus 21 [9 –4 4] days in highest quintile, p-trend < 0.001) (Fig. 2). This translated to longer overall wait times for the TAVI procedure (117 [69–170] days in lowest quintile versus 77 [42 – 147] in higher quintile, p-trend < 0.001). Patients in lower SES groups were also less likely to receive TAVI within their assigned urgency category (53.8 % in lowest quintile versus 64.8 % in highest quintile, p-trend = 0.04).

Notably, wait times were considerably longer in the public versus private hospital setting and most SES-related differences were no longer significant when stratified by public versus private treatment (Table 2). The exception was procedural wait time in the public hospital setting, which remained longer in lower SES groups (44 [27 – 72] days in lowest quintile versus 37 [14 – 67] days in highest quintile, p-trend = 0.02).

3.3. Unadjusted clinical outcomes

The overall 30-day mortality in the study cohort was 1.1 %, with no significant differences in unadjusted mortality across SES groups (p-trend = 0.76) (Table 3). This pattern was consistent at 12-months, with an overall mortality of 5.4 % in the study cohort and no significant differences observed in unadjusted mortality rates between SES groups (p-trend = 0.63). Unadjusted rates of MACE, heart failure hospitalisation, myocardial infarction, stroke, pacemaker insertion, major bleeding and major vascular complications were also comparable between SES groups at both 30 days and 12 months. Finally, hospital length of stay and rates of ICU admission were similar between SES groups.

3.4. Multivariable analyses

In the adjusted multivariable analysis, SES quintile was not an independent predictor of 30-day mortality (aOR 0.72 [95 % CI 0.14 – 3.57] in lowest quintile versus highest quintile, p = 0.68) or MACE (aOR 0.61 [95 % CI 0.29 – 1.30] in lowest quintile versus highest quintile, p = 0.20) (Table 4). Similarly, there was no significant difference in the adjusted odds of 12-month mortality (aOR 0.93 [95 % CI 0.49 – 1.78] in lowest quintile versus highest quintile, p = 0.84) or MACE (aOR 1.11 [95 % CI 0.68 – 1.83] in lowest quintile versus highest quintile, p = 0.67) across SES groups. The only predictor independently associated with 30-day mortality was STS score (aOR 1.14 [95 % CI 1.05 – 1.22] per 1 point increase in STS score, p = 0.002). Variables independently associated with 12-month mortality were a history of atrial fibrillation (aOR 1.76 [95 % CI 1.14 – 2.71], p = 0.01), eGFR < 30 mL/min/1.73 m^2

Table 2
Quality of Care Metrics.

Variable	Socioeconomic Status Quintile					P trend
	1 (Lowest) n = 204	**2 (Low)** n = 189	**3 (Middle)** n = 233	**4 (High)** n = 266	**5 (Highest)** n = 435	
All patients						
Urgent inpatient procedure	23/183 (12.6 %)	16/141 (11.4 %)	18/196 (9.2 %)	19/182 (10.4 %)	22/283 (7.8 %)	0.02
Category 1 urgency category	64/183 (35.0 %)	63/141 (44.7 %)	69/196 (35.2 %)	77/182 (42.3 %)	160/283 (56.4 %)	0.02
Workup time, days	62 (33 – 105)	54 (26 – 95)	69 (33 – 104)	63 (33 – 100)	48 (18 – 90)	0.008
Procedure wait time, days	37 (14 – 67)	27 (9 – 58)	39 (16 – 84)	30 (14 – 69)	21 (9 – 44)	<0.001
Total wait time, days	117 (69 – 170)	89 (46 – 149)	124 (71 – 179)	113 (59 – 175)	77 (42 – 147)	<0.001
Treated in recommended time, n(%)	86/160 (53.8 %)	73/125 (58.4 %)	88/178 (49.4 %)	83/163 (50.9 %)	169/261 (64.8 %)	0.04
Public hospital						
Workup time, days	75 (47 – 113)	78 (50 – 127)	85 (47—113)	85 (63 – 139)	75 (44 – 119)	0.56
Procedure wait time, days	56 (30 – 93)	58 (30 – 86)	68 (37 – 93)	58 (31 – 93)	44 (27 – 72)	0.02
Total wait time, days	143 (96 – 198)	148 (115 – 212)	150 (113 – 200)	163 (116 – 212)	147 (86 – 189)	0.98
Private hospital						
Workup time, days	33 (13 – 68)	35 (13 – 59)	39 (16 – 73)	35 (19 – 63)	32 (14 – 68)	0.94
Procedure wait time, days	16 (7 – 34)	14 (7 – 28)	16 (9 – 33)	19 (7 – 35)	14 (7 – 49)	0.83
Total wait time, days	62 (31 – 97)	54 (34 – 83)	70 (38 – 105)	62 (38 – 114)	57 (31 – 101)	0.88

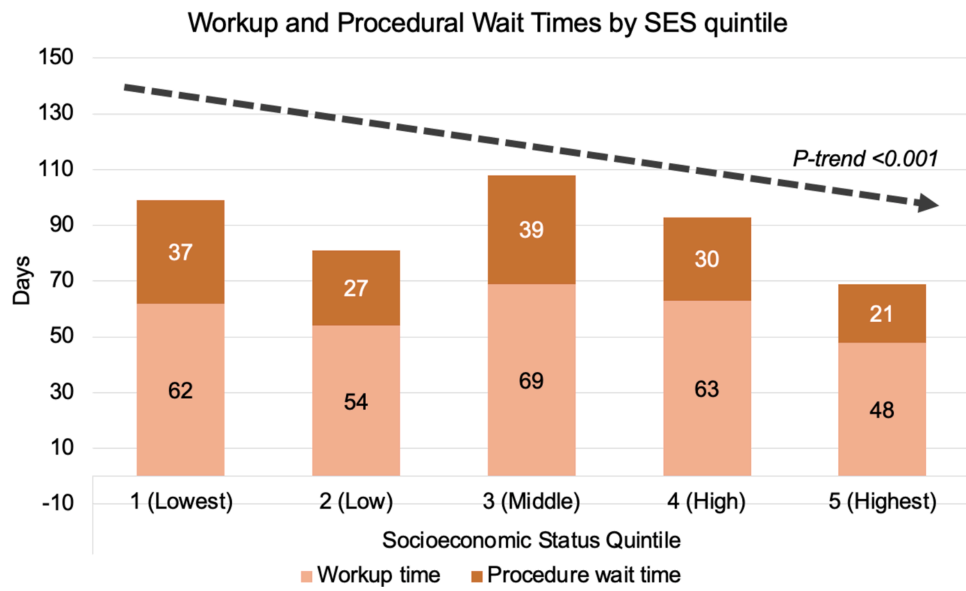

Fig. 2. Median workup and procedural wait times by socioeconomic status (SES) quintile. Patients in lower SES quintiles generally faced longer workup times and procedure wait times compared to those in higher SES quintiles. This translated to a longer overall wait time between the time of initial referral for assessment and the TAVI procedure (p-trend < 0.001). TAVI indicates transcatheter aortic valve implantation.

Table 3
Unadjusted Clinical Outcomes.

Variable	**Socioeconomic Status Quintile**					**P trend**
	1 (Lowest) n = 353	**2 (Low)** n = 338	**3 (Middle)** n = 391	**4 (High)** n = 465	**5 (Highest)** n = 915	
Hospital length of stay, days	4 (3 – 6)	5 (3 – 7)	4 (3 – 5)	4 (3 – 6)	4 (3 – 6)	0.19
ICU admission, n(%)	26 (7.4 %)	17 (5.0 %)	31 (8.0 %)	36 (7.8 %)	79 (8.7 %)	0.14
30-day outcomes						
Death, n(%)	2 (0.6 %)	4 (1.2 %)	7 (1.8 %)	4 (0.9 %)	10 (1.1 %)	0.76
MACE, n(%)	11 (3.1 %)	21 (6.2 %)	23 (5.9 %)	24 (5.2 %)	60 (6.6 %)	0.07
MI, n(%)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	2 (0.2 %)	0.15
Stroke, n(%)	2 (0.6 %)	7 (2.1 %)	11 (2.8 %)	10 (2.8 %)	17 (1.9 %)	0.36
HF hospitalisation, n(%)	7 (2.3 %)	12 (4.0 %)	5 (1.4 %)	11 (2.7 %)	45 (4.1 %)	0.17
Major vascular Cx, n(%)	6 (1.7 %)	9 (2.7 %)	10 (2.6 %)	7 (1.5 %)	9 (1.0 %)	0.07
Major bleeding, n(%)	6 (1.7 %)	3 (0.9 %)	2 (0.5 %)	8 (1.8 %)	18 (2.0 %)	0.24
PPM insertion, n(%)	52 (14.9 %)	50 (14.9 %)	49 (12.5 %)	60 (13.1 %)	132 (14.5 %)	0.86
12-month outcomes						
Death, n(%)	18 (5.1 %)	20 (5.9 %)	18 (4.6 %)	24 (5.2 %)	54 (5.9 %)	0.63
MACE, n(%)	34 (9.6 %)	35 (10.4 %)	35 (9.0 %)	44 (9.5 %)	94 (10.3 %)	0.78
MI, n(%)	3 (1.1 %)	1 (0.4 %)	1 (0.3 %)	0 (0.0 %)	3 (0.4 %)	0.20
Stroke, n(%)	3 (1.1 %)	10 (3.7 %)	12 (4.0 %)	12 (3.2 %)	19 (2.5 %)	0.77
HF hospitalisation, n(%)	12 (5.7 %)	5 (2.4 %)	4 (1.8 %)	11 (3.7 %)	28 (4.4 %)	0.85
Major vascular Cx, n(%)	6 (2.2 %)	9 (3.3 %)	11 (3.7 %)	8 (2.2 %)	10 (1.3 %)	0.08
Major bleeding, n(%)	7 (2.6 %)	4 (1.5 %)	3 (1.0 %)	8 (2.1 %)	22 (2.9 %)	0.30
PPM insertion, n(%)	54 (19.2 %)	52 (18.5 %)	41 (16.5 %)	60 (15.8 %)	141 (18.1 %)	0.66

HF indicates heart failure; ICU, intensive care unit; MACE, major adverse cardiovascular events; PPM, permanent pacemaker.

(aOR 2.22 [95 % CI 1.07 – 4.42], p = 0.03), and aortic valve area (aOR 0.19 [95 % CI 0.06 – 0.60] for every 1 cm^2 increase in area, p = 0.005).

4. Discussion

This study assessed the impact of SES on clinical characteristics, treatment, and outcomes among patients undergoing TAVI for severe AS across three high-volume centres in Melbourne, Australia. Our study had several key findings: 1) lower SES patients were younger and more likely to be obese, diabetic, and have a history of heart failure or myocardial infarction compared to those in higher SES groups, 2) lower SES patients had less private health insurance and were more likely to receive care in public hospitals, 3) lower SES patients had markers of more advanced disease at the time of intervention and more frequently underwent TAVI as an urgent procedure, but for elective procedures faced longer workup and procedural wait times, and 4) despite these disparities, no significant differences in 30-day or 12-month mortality or MACE were found between SES groups.

SES is a well-documented determinant of healthcare access and outcomes [4,5]. Even in countries with universal healthcare coverage such as Australia, prior research has highlighted pronounced disparities in both the delivery of care and health outcomes across a spectrum of medical conditions 15, 16, 18]. In the context of AS, studies from other healthcare settings have revealed disparities in access to TAVI, with TAVI programs often concentrated in metropolitan areas servicing higher SES populations, [19] lower rates of TAVI among vulnerable

Table 4
Multivariable logistic regression analysis.

	Socioeconomic Status Quintile									
	1 (Lowest)			2 (Low)		3 (Middle)		4 (High)		5 (Highest)
	aOR (95 % CI)	P-value	aOR (95 % CI)	P-value	aOR (95 % CI)	P-value	aOR (95 % CI)	P-value	aOR (95 % CI)	P-value
30-day mortality	0.72 (0.14 – 3.57)	0.68	0.91 (0.21 – 3.85)	0.89	1.51 (0.42 – 5.39)	0.53	1.16 (0.33 – 4.11)	0.82	REF	N/A
30-day MACE	0.61 (0.29 – 1.30)	0.20	0.99 (0.52 – 1.88)	0.97	1.01 (0.54 – 1.89)	0.97	1.21 (0.70 – 2.11)	0.69	REF	N/A
12-month mortality	0.93 (0.49 – 1.78)	0.84	0.78 (0.40 – 1.54)	0.48	0.98 (0.52 – 1.87)	0.96	1.07 (0.61–1.88)	0.24	REF	N/A
12-month MACE	1.11 (0.68 – 1.83)	0.67	0.94 (0.56 – 1.57)	0.80	1.17 (0.72 – 1.91)	0.52	1.12 (0.72 – 1.77)	0.51	REF	N/A

aOR indicates adjusted odds ratio; and MACE, major adverse cardiovascular events.

socioeconomic groups, [20] and worse outcomes among patients with psychosocial risk factors undergoing TAVI or SAVR [21]. However, to our knowledge, no studies to date have evaluated whether these disparities exist in the Australian setting.

Our study offers important insights into the relationship between SES and TAVI care in Australia. Consistent with studies of other cardiovascular conditions, lower SES patients were younger but had a greater burden of comorbidities compared to those in higher SES groups. Lower SES patients also had a lower baseline AVA and dimensionless index, more pulmonary hypertension, and were more likely to undergo TAVI as an urgent procedure, reflecting a more advanced stage of AS at the time of intervention. These disparities likely stem from complex factors, including barriers in access to primary care and specialist consultations leading to delayed detection of AS and referral for TAVI, as well as financial, geographical, and health literacy challenges.

Our study also highlighted significant disparities in pre-procedural care. Patients of lower SES faced longer workup and procedural wait times, with the median total wait time for those in the lowest SES quintile exceeding that of the highest quintile by over 50 %. This difference was closely related to the care setting, as private hospitals (predominantly utilised by higher SES patients) had significantly shorter wait times. Our findings highlight the sobering observation that, despite Australia's universal healthcare system, patients without private health insurance may face substantial barriers to accessing elective procedures like TAVI. Notably, the public hospital in the ACE registry is one of the highest volume TAVI centres in Australia and likely reflects a best-case scenario for wait times in the public sector. The gap between private and public sectors may be even more pronounced in other regions. These findings are concerning given that severe AS rapidly progresses once symptoms manifest. Prolonged wait times for TAVI translate not only to a period of diminished quality of life, but also a critical window of heightened risk for clinical deterioration.

Although TAVI has been performed in Australia since 2008, its adoption has lagged behind other developed nations, hampered by limitations in public funding for the procedure [22]. While the introduction of a Medicare Benefits Schedule number in 2017 facilitated improved accessibility of TAVI in Australia, utilisation of TAVI in the public setting remains constrained by funding that restricts the number of procedures per hospital annually [22]. Our study suggests that low SES patients, who rely more heavily on public healthcare, may be disproportionately affected by these factors. This observation provides impetus for policy changes to enhance TAVI accessibility across all socioeconomic groups, especially in light of evidence supporting the cost-effectiveness of TAVI compared to SAVR in Australia [6,7].

Despite differences in demographics and pre-procedural care, key procedural factors were consistent across SES groups. For example, the choice of arterial access is a critical determinant of TAVI outcomes, as different access routes can significantly impact procedural safety and patient prognosis [23]. Notably, transfemoral access has been linked to lower mortality rates, driven by reduced *peri*-procedural complications such as bleeding and stroke [23]. In our study, over 95 % of patients underwent transfemoral access, with no significant difference in the proportion of transfemoral access used across SES groups. Similarly, the type of valve prosthesis used was comparable across SES groups, with approximately two-thirds of the cohort receiving a self-expanding valve and the remainder receiving a balloon-expandable valve.

The consistency in key procedural approaches may have contributed to the equitable clinical outcomes observed in our study, as we found no significant differences in mortality or complication rates at 30 days and 12 months across SES groups. The absence of procedural biases further enhances the comparability of outcomes across different SES groups. This finding is reassuring, suggesting a levelling effect exerted by the standardised care protocols and concentrated expertise within specialised TAVI centres once patients have accessed the procedure. Our findings align with prior Australian studies evaluating the impact of socioeconomic disadvantage on post-cardiac surgery and post-myocardial infarction outcomes [18,24]. Similarly, a study comparing TAVI outcomes in Australian private versus public hospitals found no significant difference in procedural success or mortality, supporting the notion of standardised and high-quality care provided within specialised centres [9].

Finally, we noted an uneven distribution of SES quintiles within our study population, with disproportionate representation of patients in higher SES quintiles. This discrepancy most likely reflects a selection bias within the ACE registry, as two of the three hospitals included are private hospitals and cater to a higher socioeconomic demographic. An alternative explanation is true underrepresentation of lower SES groups among patients receiving TAVI, a pattern that has been observed in other healthcare settings [20]. The ACE registry's inclusion of only patients who have undergone TAVI precludes an analysis of disease prevalence or referral rates for TAVI within the broader population of patients with AS. Further investigation is warranted to understand where exactly disparities begin in the continuum of AS care.

4.1. Limitations

Our study has several limitations. First, it was an observational registry-based study and therefore we were unable to account for all possible confounders. However, data in the ACE registry were prospectively collected and its observational nature meant that results are reflective of routine clinical practice. Secondly, we used neighbourhood SES as a surrogate marker of SES as individual SES data were not available. Although this is a well validated proxy for individual SES, not all aspects of a patient's SES may have been captured. Thirdly, the ACE registry only included patients undergoing TAVI at three hospitals in Victoria, Australia, two of which were private hospitals. Thus, the results may not be generalisable to the broader population of patients undergoing TAVI in other Australian states or globally.

5. Conclusion

Among patients with severe AS undergoing TAVI in the Australian setting, lower SES is linked to a higher burden of comorbidities, more reliance on public hospital care, and longer procedural wait times. However, there were no significant differences in 30-day or 12-month mortality or adverse events across SES groups. These findings underscore the Australian healthcare system's ability to deliver equitable post-procedural outcomes once care is accessed. Nonetheless, the pre-TAVI disparities emphasise the need for policy and system reforms to ensure all patients have timely access to lifesaving procedures.

CRediT authorship contribution statement

Jennifer Zhou: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Shane Nanayakkara:** Writing – review & editing, Supervision, Software, Methodology, Formal analysis, Data curation. **Rozanne Johnston:** Writing – review & editing, Methodology, Data curation. **Ellen Gardner:** Writing – review & editing, Methodology, Investigation, Data curation. **Nay Min Htun:** Writing – review & editing, Methodology, Investigation. **Sonny Palmer:** Writing – review & editing, Methodology, Investigation. **Samer Noaman:** Writing – review & editing, Investigation, Data curation. **Liam Guiney:** Writing – review & editing, Investigation, Data curation. **David M Kaye:** Writing – review & editing, Supervision, Resources. **Antony S. Walton:** Writing – review & editing, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Dion Stub:** Writing – original draft, Resources, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Potential conflicts of interest.

TW is a proctor for Medtronic, Edwards and Abbott, is on the medical advisory board for Medtronic, Edwards and Abbott, and receives grant support from Medtronic, Edwards and Abbott. DS is on the medical advisory board Medtronic, Edwards, Abbott and Anteris. All other authors have no disclosures or conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcha.2024.101561.

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