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Impact of social deprivation on outcome following transcatheter aortic valve implantation (TAVI)

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ABSTRACT

Objectives We sought to evaluate whether socioeconomic status influences outcome after first-time transcatheter aortic valve implantation (TAVI).

Method This is a single-centre study carried out in Swansea, South West Wales, UK between 5 November 2009 and 10 June 2018. Data included age, gender, domiciliary postal code, comorbidities, complications post-TAVI, length of stay, follow-up time and survival status. The Welsh Index of Multiple Deprivation, 2014 was used to stratify cases by level of social deprivation according to domiciliary postal codes.

Results Study population was 387 patients of whom 213 (54.8%) were men with mean age ±SD of 82.8±8.3 years. Patients, who were less deprived (296 (76.4%)), were more likely to be older (83.5±7.9 vs 80.4±9.3, p<0.05) and to be married (83.2% vs 69.7%, p<0.05). Conversely, 'more deprived' patients (91 (23.6%)) were more likely to have a longer stay in hospital as compared with patients in the 'less deprived group' (29.6±32.7 days vs 21.3±21.1 days, p<0.05). However, 30-day, 1-year and 3-year survival/mortality rates were similar across all socioeconomic levels.

Conclusions This is the first study in which social deprivation has been investigated as a risk factor for mortality in a high-risk group of patients with severe aortic stenosis undergoing TAVI. Residing in a 'more deprived' area in South West Wales is not associated with adverse outcome following TAVI but patients who are 'more deprived' tend to stay longer in hospital compared with patients who are 'less deprived'.

Key questions

What is already known about this subject?

► Transcatheter aortic valve implantation (TAVI) is widely used for the treatment of severe symptomatic aortic stenosis in patients who are deemed to be at high to intermediate high risk to undergo surgical aortic valve replacement, although recent evidence is emerging for its utility in low-risk populations as well. As a result, it is likely that volumes of TAVI procedures will increase significantly in the future.

What does this study add?

► The interaction between outcomes following TAVI and socioeconomic status has received limited attention until now. This is the first study in which social deprivation has been investigated as a risk factor for mortality in a high-risk group of patients with severe aortic stenosis undergoing TAVI.

How might this impact on clinical practice?

► The findings of this study may, therefore, impact on procedural planning and discharge strategies given the association between socioeconomic deprivation and the increased prevalence of heart valve disease. Likewise, the increasing volume of TAVI implants that are likely to occur as a result of the recently published low-risk trials of TAVI versus conventional surgery.

INTRODUCTION

Aortic stenosis (AS) has become an increasingly more common global occurrence in increasingly elderly populations.[1] Transcatheter aortic valve implantation (TAVI) is widely used for the treatment of severe symptomatic AS in patients who are deemed to be at high to intermediate high risk to undergo surgical aortic valve (AV) replacement,[2] although recent evidence is emerging for its utility in low-risk populations as well.[3 4] As a result, it is likely that volumes of TAVI procedures will increase significantly in the future.

The relationship between socioeconomic status and various components of health is well established. Studies have shown that residing in the most deprived areas in the UK contributes to a 3.5-fold greater risk for coronary heart disease (CHD) mortality than living in the least deprived areas[5 6] and is associated with earlier development of CHD and greater prevalence of CHD-associated risk factors.[7–9] The OxVALVE Population Cohort Study (OxVALVE) carried out in the UK found that the prevalence of undiagnosed CHD was higher in lower socioeconomic groups.[9]

The interaction between outcomes following TAVI and socioeconomic status has received limited attention until now. The aim

of this study is to investigate the relationship between socioeconomic factors and outcomes following TAVI using deprivation measures calculated on the basis of domicile postcodes, in an area of the UK with high levels of socioeconomic deprivation.

METHODS

Setting and sample

This retrospective case observational study identified 387 patients with severe AS (AV area $\leq 1\,cm^2$ and/or AV area index $\leq 0.60\,cm^2/m^2$ and/or AV velocity $\geq 4\,m/s$) who underwent first-time TAVI between 5 November 2009 and 10 June 2018 at Morriston Cardiac Centre, Swansea. Patients undergoing 'valve-in-valve' TAVI for degenerate aortic bioprostheses were excluded. Demographic data were collected using electronic medical records. Domicile postal codes were recorded as part of demographic data. On the basis of these postal codes, patients were assigned a deprivation code using the Welsh Index of Multiple Deprivation, 2014 (WIMD).

The WIMD is the official measure of relative deprivation for small areas in Wales produced by the Welsh Government and was developed as a tool to identify and understand deprivation in Wales. Eight domains of deprivation are included: employment, income, education, health, community safety, geographical access to services, housing and physical environment. Each domain is made up of a number of indicators and there are 35 indicators in total that compromise the WIMD 2014.

The income domain indicator has the highest weighting (23%) for the overall WIMD score and was used as a marker of deprivation in this study for a number of reasons. In contrast to the WIMD rank (which is based on a relative score), the income domain indicator is an absolute score, which provides the percentage of those living in the area receiving income-related benefits. It has an extremely high correlation with the overall deprivation index.[10] Using the WIMD rank, each patient was assigned the corresponding income domain indicator score and this was used as an absolute measure of deprivation in the analysis.[11] In order to analyse whether there were any differences in the patient demographics, injury mechanisms and outcomes, patients were classified as 'more deprived' if their income domain indicator score was 22% or more and 'less deprived' if their score was 21% or less. This cut-off value corresponds to the top 30% of the most deprived areas in Wales.[12]

Statistical analysis

Analysis was performed using the statistical computing environment R (R Studio open source developing team, V.1.1.456). Baseline characteristics were presented as mean and SD for continuous variables, or numbers and percentages for categorical variables. Differences

Table 1 Baseline characteristics for patients undergoing TAVI between 2009 and 2018 at Morriston Cardiac Centre

Variable	All (n=387)	Less deprived (n=296)	More deprived (n=91)	P value
Age (mean±SD)	82.8±8.3	83.5±7.9	80.4±9.3	0.004
Creatinine (mean±SD)	128.4±96.4	126±94.3	137±104.2	0.395
BMI (mean±SD)	27.3±15.4	27.2±17.1	27.9±7.3	0.588
Sex—n male (%)	213 (54.8)	166 (56.1)	47 (51.6)	0.457
Marital status—n married (%)	199 (79.3)	153 (83.2)	46 (69.7)	0.020
Diabetes—n (%)	95 (25.7)	75 (26.6)	20 (23.5)	0.572
Smoking history—n (%)	226 (64)	173 (63.6)	51 (64.6)	0.877
Renal disease—n (%)	31 (8.4)	24 (8.5)	7 (8.2)	0.936
On dialysis—n (%)	13 (3.5)	9 (3.2)	4 (4.7)	0.512
Previous MI—n (%)	106 (28.3)	85 (29.8)	20 (23)	0.215
Lung disease—n (%)	120 (32.4)	86 (30.4)	34 (40)	0.097
Previous stroke/TIA—n (%)	55 (14.7)	43 (15.1)	11 (12.5)	0.546
Previous cardiac surgery—n (%)	100 (26.7)	80 (28.1)	20 (22.7)	0.323
CCS Angina 3/4 n (%)	56 (15.5)	42 (15.2)	14 (16.7)	0.748
NYHA class III–IV—n (%)	345 (95)	263 (94.9)	81 (95.3)	0.897
CSHA frailty moderate/severe—n (%)	88 (28.7)	67 (28.3)	21 (30)	0.779
Poor LV function—n (%)	66 (19)	43 (16.5)	23 (26.7)	0.035
Triple vessel coronary disease—n (%)	50 (14.4)	39 (14.9)	11 (13.1)	0.685

Data are split by deprivation status. P values calculated using two sample t-test with unequal variance (continuous variables) or X^2 test (categorical variables)

BMI, body mass index; CSHA, Canadian Study of Health and Ageing Frailty Score; LV, left ventricular; MI, myocardial infarction; NYHA, New York Heart Association; TAVI, transcatheter aortic valve implantation; TIA, transient ischemic attack.

Table 2 Procedural and outcome variables for patients undergoing TAVI at Morriston Cardiac Centre

Variable	All (n=387)	Less deprived (n=296)	More deprived (n=91)	P value
Femoral approach—n %	307 (89.2)	231 (88.5)	74 (91.4)	0.470
General anaesthesia—n %	131 (38.3)	102 (39.2)	28 (35)	0.496
Complication: MI—n %	0 (0)	0 (0)	0 (0)	–
Complication—death—n %	3 (0.9)	3 (1.2)	0 (0)	–
Complication—tamponade—n %	5 (1.5)	5 (2)	0 (0)	–
Complication—major apical cannulation—n %	0 (0)	0 (0)	0 (0)	–
Complication—major vascular injury—n %	5 (1.5)	4 (1.6)	1 (1.2)	0.798
Complication—bailout PCI—n %	0 (0)	0 (0)	0 (0)	–
Complication—stroke—n %	1 (0.3)	1 (0.4)	0 (0)	–
Complication—cardiogenic shock—n %	3 (0.9)	3 (1.2)	0 (0)	–
Emergency valve in valve—n %	0 (0)	0 (0)	0 (0)	–
Device embolisation—n %	2 (0.6)	2 (0.8)	0 (0)	–
Device migration—n %	2 (0.7)	1 (0.5)	1 (1.5)	0.415
GI haemorrhage—n %	0 (0)	0 (0)	0 (0)	–
Tamponade postprocedure—n %	1 (0.4)	1 (0.5)	0 (0)	–
Platelet transfusion—n %	3 (1.1)	2 (1)	1 (1.5)	0.741
Blood transfusion—n %	21 (7.8)	17 (8.5)	3 (4.5)	0.279
New dialysis—n (%)	30 (11.2)	29 (14.6)	1 (1.5)	0.003
ITU stay (mean±SD)	1.8±2.2	1.9±2.5	1.6±1.1	0.087
Total stay (mean±SD)	23.2±24.5	21.3±21.1	29.6±32.7	0.025
In-hospital death	23 (5.9)	17 (5.7)	6 (6.7)	0.735

Data are split by deprivation status. P values calculated using two sample t-test with unequal variance (continuous variables) or X^2 test (categorical variables)

ITU, intensive treatment unit; MI, myocardial infarction; PCI, percutaneous coronary intervention; TAVI, transcatheter aortic valve implantation.

between the baseline characteristics were analysed using two sample t-test with unequal variance and X^2 tests.

Survival analysis was carried out using Kaplan-Meier actuarial outcome analysis to determine difference in 30-day, 1-year and 3-year mortality. HRs for risk of mortality were constructed using Cox proportional HR modelling based on deprivation. Multivariate analysis was carried out to adjust for baseline characteristics using multiple logistic modelling with resulting ORs and 95% CIs presented as forest plots. Significance was defined at a p<0.05.

All patient information was anonymised and de-identified prior to analysis.

RESULTS
Patient population and characteristics
Between 5 November 2009 and 10 June 2018, 387 consecutive patients underwent first-time TAVI at Morriston Cardiac Centre, Swansea. The mean patient follow-up was 578 days. The patient population comprised 213 men (54.8%) and mean age at TAVI was 82.8 years (SD 8.3) with a range of 47–100 years. There were 91 patients (23.5%) deemed as 'more deprived' who underwent TAVI compared with 296 'less deprived'. Patients who

were less deprived were more likely to be older (83.5±7.9 vs 80.4±9.3, p<0.05) and to be married (83.2% vs 69.7%, p<0.05). Baseline characteristics are listed in table 1.

Conversely 'more deprived' patients were more likely to have a longer stay in hospital as compared with patients in the 'less deprived group' (29.6±32.7 days vs 21.3±21.1 days, p<0.05). Procedural and in-hospital outcome variables are shown in table 2.

Overall survival based on deprivation status
Kaplan-Meier survival analysis showed that there was no significant difference in survival between deprivation groups at 30-day, 1-year and 3-year end points (figure 1A–C). Statistical analysis using a Cox proportional hazards analysis and log-rank tests showed no increased hazards for mortality (figure 1D).

Multivariate analysis of baseline characteristics
Forest plot of multiple logistic regression modelling of mortality, adjusted for age, sex, marital status, diabetes, smoking status, lung disease and left ventricular function can be seen in figure 2. This was carried out at 30-day, 1-year and 3-year endpoints. It shows that even after adjusting for these variables, deprivation status does not
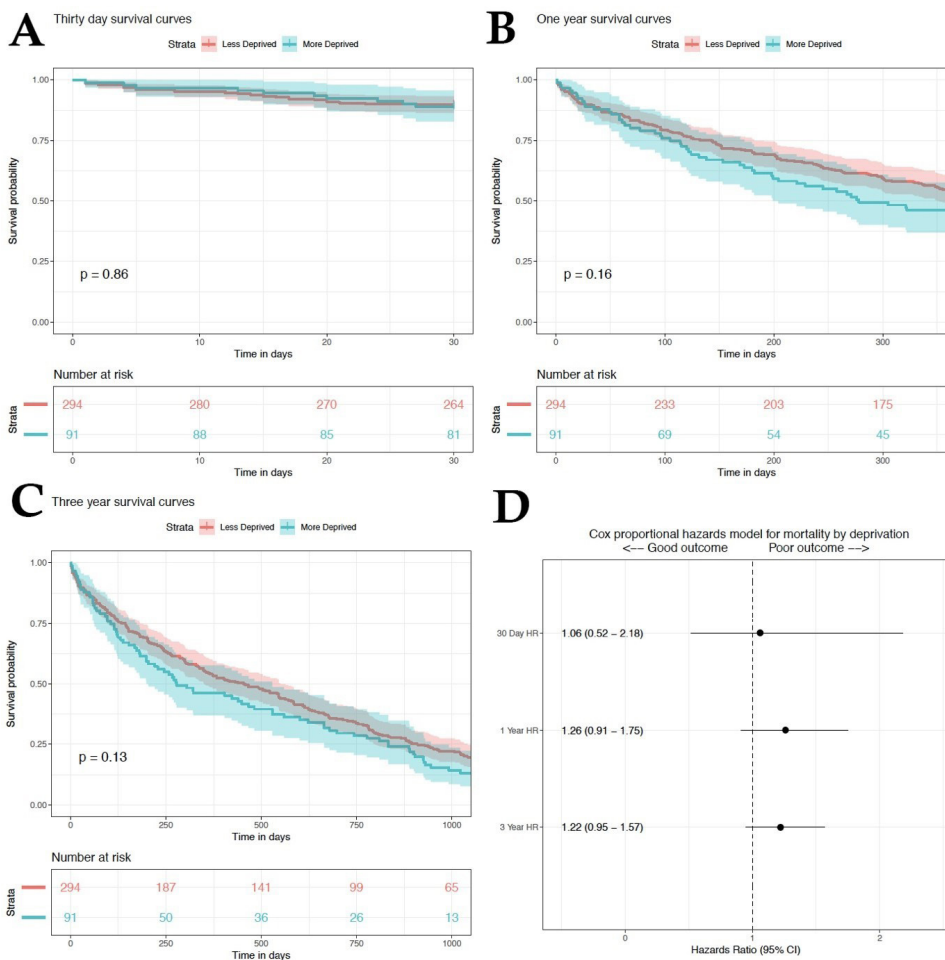
Figure 1 Survival analysis of patients who underwent TAVI stratified by deprivation status. There were no statistically significant differences in survival between groups at 30 days (A), 1-year (B) or 3-year (C) as determined by log-rank testing. Cox proportional hazards are displayed in (D) confirming no statistical significance by 95% CIs. TAVI, transcatheter aortic valve implantation.

increase short-term or intermediate-term mortality in patients undergoing TAVI procedures.

DISCUSSION

This study is the first to date to investigate associations between deprivation and outcomes in patients undergoing TAVI. We found that socioeconomic status had no impact on survival rate up to 3 years after TAVI. However, low socioeconomic status was independently associated with a longer stay in hospital post-TAVI. These findings are of importance for two reasons. First, given the association between socioeconomic deprivation and
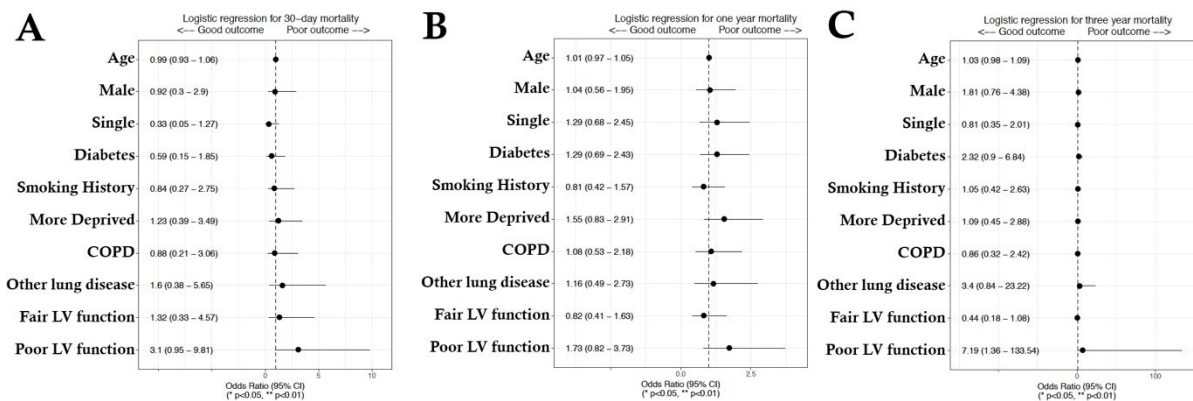

Figure 2 Forest plot of multiple logistic regression modelling of mortality, adjusted for age, sex, marital status, diabetes, smoking status, lung disease and LV function. COPD, chronic obstructive pulmonary disease; LV, left ventricular.

the increased prevalence of heart valve disease[9] and second, the increasing volume of TAVI implants that are likely to occur as a result of the recently published low-risk trials of TAVI versus conventional surgery.[3 4]

The design of our study built on previous evidence that factors such as coronary artery disease (CAD), left ventricular dysfunction and frailty varied in their prevalence according to deprivation status. However, we found that none of these factors influenced mortality following TAVI, in our 'more deprived' study population. The influence of coexisting CAD has been reported to have a detrimental effect on survival rate if patients are not revascularised in relation to surgical valve replacement.[13 14] According to The Euro Heart Survey on Valvular Heart Disease, fewer than 25% patients undergoing single aortic or mitral valve replacement have additional coronary artery bypass graft (CABG).[15] As ischaemic heart disease generally has a higher prevalence in a disadvantaged population, a higher rate of coexisting CAD would be expected among valve disease patients from a disadvantaged background, and therefore, a higher operative mortality rate in this group.[16–18] Either this was not the case, and we found no difference in angiographically defined three vessel CAD between the deprivation groups in our population, or coexisting CAD did not play a major role for the operative survival after percutaneous valve replacement in our UQQQcohort, irrespective of socioeconomic level.

Being domiciled in a deprived community has been reported a risk factor for outcome 3 years after coronary bypass grafting[19] but no Welsh study was available for comparison. There are other several possible reasons for a poorer long-term outcome for disadvantaged patients after major cardiac procedures. Low socioeconomic status has been associated with lower rates of exercise and conversely higher rates of smoking, alcohol intake and unemployment rates.[19 20] Also higher lipid levels, a higher prevalence of obesity and diabetes, and hypertension among the socially most deprived may all contribute to a higher long-term mortality rate.[18–20] Furthermore, several studies have shown that economically disadvantaged subjects are less likely to benefit from evidence-based advances in medical care or undergo invasive cardiac evaluation and revascularisation than their less deprived counterparts.[13 15 21] It has been suggested that more deprived people may not be able to afford prescription drugs.[15] Furthermore, diseases other than CAD (eg, cancer, infections and hip fractures) have been reported more frequently among patients from socially deprived areas and may contribute to a poorer long-term outcome.[22 23]

Limitations

This study has a number of limitations. One potential limitation of the study is that our small sample size, so the results are only generalisable to high-risk TAVI patients in a UK population. As a result of the study design and the inherent nature of patients, a number of the independent variables investigated were potentially interdependent and an increase in one variable inadvertently leads to an increase in another.

Multivariable logistic regression was used in an attempt to address this issue of collinearity. It is also possible that a confounding variable that influences the results was not considered in the data collection or analysis. It could, therefore, be suggested that the discovered association between social deprivation and prolonged length of stay is the result of both risk factor and outcome being related to common underlying unmeasured pathologies. Also, our database did not record cause of death. In prognostic clinical research, however, this is difficult to overcome due to the nature of the study population, and therefore, the results of the study should be interpreted with this in mind.

Another study limitation involves the use of the WIMD 2014 codes and the income domain indicator as the measure of social deprivation. This is a measure of area rather than individual deprivation and it is important to consider therefore that not everyone living in a deprived area is deprived, and that not all deprived people live in deprived areas. It should also be highlighted subsequent analysis of components of a composite outcome measure could lead to erroneous conclusions due to multiple testing. This should be taken into account when considering the results of this study.

CONCLUSIONS

This is the first study in which socioeconomic deprivation has been investigated as a risk factor for mortality following TAVI. The results of the study indicate that a disadvantaged social background did not impact on survival in a high-risk group of patients with symptomatic severe AS undergoing TAVI. Social deprivation, however, was found to be a risk factor for prolonged length of in-hospital stay and may, therefore, influence procedural planning and discharge strategies.

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