4-1-2021

Racial, ethnic and socioeconomic disparities in patients undergoing left atrial appendage closure

Robbie Sparrow

Shubrandu Sanjoy

Yun-Hee Choi

Islam Y. Elgendy

Hani Jneid

See next page for additional authors

Authors
Robbie Sparrow, Shubrandu Sanjoy, Yun-Hee Choi, Islam Y. Elgendy, Hani Jneid, Pedro A. Villablanca, David R. Holmes, Ashish Pershad, Chadi Alraies, Luciano A. Sposato, Mamas A. Mamas, and Rodrigo Bagur

Original research

Racial, ethnic and socioeconomic disparities in patients undergoing left atrial appendage closure

Robbie Sparrow [1], Shubrandu Sanjoy,[2] Yun-Hee Choi,[2] Islam Y Elgendy [3], Hani Jneid,[4] Pedro A Villablanca,[5] David R Holmes,[6] Ashish Pershad,[7] Chadi Alraies,[8] Luciano A Sposato [2,9,10] Mamas A Mamas [11] Rodrigo Bagur [2,10,11]

► Additional supplemental material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/heartjnl-2020-318650).

For numbered affiliations see end of article.

Correspondence to
Dr Rodrigo Bagur, London Health Sciences Centre, Western University, London N6A 5A5, Canada; rodrigobagur@yahoo.com

Received 11 November 2020
Revised 25 February 2021
Accepted 26 February 2021

Check for updates

To cite: Sparrow R, Sanjoy S, Choi Y-H, *et al*. *Heart* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/heartjnl-2020-318650

ABSTRACT

Objective This manuscript aims to explore the impact of race/ethnicity and socioeconomic status on in-hospital complication rates after left atrial appendage closure (LAAC).

Methods The US National Inpatient Sample was used to identify hospitalisations for LAAC between 1 October 2015 to 31 December 2018. These patients were stratified by race/ethnicity and quartiles of median neighbourhood income. The primary outcome was the occurrence of in-hospital major adverse events, defined as a composite of postprocedural bleeding, cardiac and vascular complications, acute kidney injury and ischaemic stroke.

Results Of 6478 unweighted hospitalisations for LAAC, 58% were male and patients of black, Hispanic and 'other' race/ethnicity each comprised approximately 5% of the cohort. Adjusted by the older Americans population, the estimated number of LAAC procedures was 69.2/100 000 for white individuals, as compared with 29.5/100 000 for blacks, 47.2/100 000 for Hispanics and 40.7/100 000 for individuals of 'other' race/ethnicity. Black patients were ~5 years younger but had a higher comorbidity burden. The primary outcome occurred in 5% of patients and differed significantly between racial/ethnic groups (p<0.001) but not across neighbourhood income quartiles (p=0.88). After multilevel modelling, the overall rate of in-hospital major adverse events was higher in black patients as compared with whites (OR: 1.60, 95% CI 1.22 to 2.10, p<0.001); however, the incidence of acute kidney injury was higher in Hispanics (OR: 2.19, 95% CI 1.52 to 3.17, p<0.001). No significant differences were found in adjusted overall in-hospital complication rates between income quartiles.

Conclusion In this study assessing racial/ethnic disparities in patients undergoing LAAC, minorities are under-represented, specifically patients of black race/ethnicity. Compared with whites, black patients had higher comorbidity burden and higher rates of in-hospital complications. Lower socioeconomic status was not associated with complication rates.

INTRODUCTION

Patients with atrial fibrillation (AF) are at a significantly elevated risk of embolic stroke,[1] and oral anticoagulation therapy is the mainstay for its prevention. However, many patients with AF are not candidates for anticoagulation because they have contraindications such as prior bleeding episodes or suboptimal management. In those situations, left atrial appendage closure (LAAC) is a non-pharmacological option to reduce the risk of stroke.[2 3]

Previous studies have shown that racial and socioeconomic disparities exist in both AF management and structural heart disease interventions,[4 5] but how these inequalities influence individuals undergoing LAAC is not fully understood. As LAAC procedures continue to increase, it is important to understand the characteristics of the patients receiving the procedure and whether factors exist that impact postprocedural outcomes. With that information, physicians can both select patients who may derive the optimal benefit from the procedure, while at the same time make efforts to reduce factors that lead to inequalities in access and outcomes. Therefore, we aimed to explore the impact of self-reported race/ethnic and socioeconomic status on in-hospital complication rates in individuals undergoing LAAC.

METHODS

Data source and study population

The data source for this study was the National Inpatient Sample (NIS), a US all-payer inpatient healthcare database.[6] All hospitalisations in the NIS who had undergone LAAC, as a primary procedure, between 1 October 2015 and 31 December 2018 were included in the study. Eligible participants were identified with the International Classification of Diseases 10th Revision (ICD-10) procedure code 02L73DK (occlusion of left atrial appendage with Watchman device (Boston Scientific, Natick, Massachusetts, USA), percutaneous approach). Information on patients' demographics was extracted from the database, including age, sex, race and median household income according to residential zip code. Patient records were excluded from the cohort if they did not include race or zip code income quartile.

The CHA_2DS_2-VASc score was used to categorise preprocedural thromboembolic risk; its components include congestive heart failure, hypertension, age 65 to 74 years and ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack (TIA), vascular disease (including previous myocardial infarction) and female sex.[7 8] The Charlson comorbidity index (CCI) and Elixhauser comorbidity score (ECS) were used to assess the comorbidity burden.[9–14] These comorbidity measurements were calculated by identifying the ICD-10 codes, which corresponded to each component of the scores.

Study outcomes

The primary study outcome was the occurrence of in-hospital complication, defined as the composite of bleeding complications, cardiac complications, vascular complications, acute kidney injury (AKI) and postprocedural stroke or TIA. Only ICD-10 codes that explicitly referenced postprocedural haemorrhage or haematoma were included in bleeding complications. Cardiac complications included myocardial infarction, pericardial complications, complete heart block, cardiogenic shock and need for emergency open cardiac surgery. In-hospital complications were identified using ICD-10 codes, in the same manner as described above for comorbidities and are detailed in online supplemental table 1.

Statistical analysis

The study population was stratified by self-reported race/ethnicity and by quartiles of median household income according to zip code. The NIS database categorises individuals into six racial groups: white, black, Hispanic, Asian/Pacific Islander, Native American and 'other'. The first three groups were left unchanged for this study, and the last three were combined into an 'other race/ethnicity' group due to low numbers of patients in each individual group. Median zip code incomes were $0–$45 999, $46 000–$58 999, $59 000–$78 999 and above $79 000 for quartiles 1–4 in 2018, respectively.

Comparisons were performed between the baseline characteristics of each racial group and each zip code income quartile, respectively. Categorical variables were expressed as counts and proportions and were analysed using χ^2 or Fisher's exact test. Continuous variables are expressed median (IQR) given their non-normal distribution. The Kruskal-Wallis test was used to compare differences between groups, and pair-wise comparisons of racial/ethnic group ages were evaluated with the Mann-Whitney U test with Bonferroni correction. Table cells with less than 10 discharge records are displayed as '<10' because the exact count could not be reported under the Healthcare Cost and Utilization Project data use agreement. Adjusted p values for each variable were computed adjusting for a survey sampling design by discharge-level weights, cluster and strata provided by NIS and recommended by the Agency for Healthcare Research and Quality during survey-specific analysis.[15]

The Cochran-Armitage trend test was used for detecting linear trends for changes in the number of LAAC procedures among individuals of white versus non-white race/ethnicity over the time. Length of stay (LOS) was calculated by subtracting the admission date from the discharge date.

Because the NIS database has a two-level hierarchical structure (patients are nested within hospitals), to account for intracluster correlation within hospitals, multilevel modelling was performed to allow the intercepts to vary across hospitals and sampling weights were adjusted. The associations between race/ethnicity and income quartiles, and in-hospital complications were assessed using multilevel multivariable logistic regression models adjusted for age, sex and relevant comorbidities. The models stratified by racial/ethnic groups were adjusted by median neighbourhood income quartiles, and conversely, the models stratified by income quartiles were adjusted by race. Relevant comorbidities were selected a priori based on their clinical significance that may directly influence in-hospital outcomes and also those with a p value <0.10 as determined by univariable analysis (online supplemental table 2). Two similar models were used to assess the impact of individual comorbidities on in-hospital complications, one of which was adjusted by race/ethnicity and the other by income quartiles. White patients and those from the top income quartile were used as reference groups for all

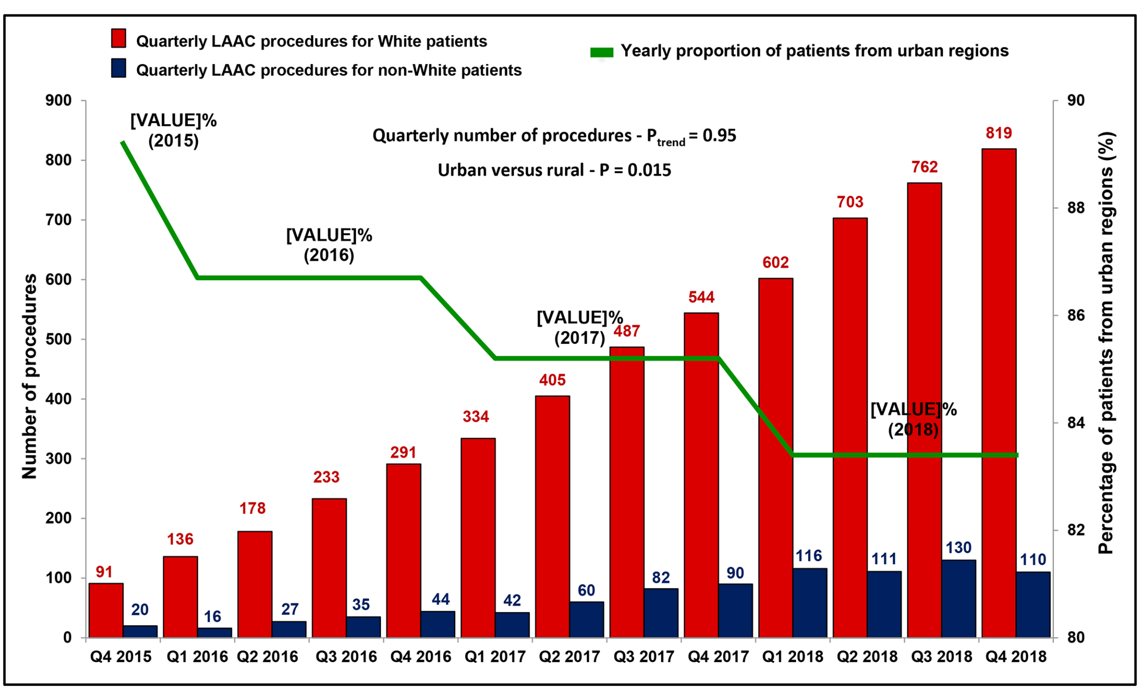

Figure 1 Quarterly number of LAAC procedures performed (red/navy) for patients of white and non-white race/ethnicity and yearly proportion of patients from urban versus rural regions (green). Cochran-Armitage trend test demonstrated no statistically significant difference in procedures performed over the time between white and non-white race/ethnicity (P_{trend}=0.95). Significant change in the proportion of patients from urban versus rural regions was observed over the time (p=0.015). The right-hand y-axis does not start from zero. LAAC, left atrial appendage closure.

Table 1 Baseline characteristics of the study population stratified by race/ethnicity

Patient characteristics	All n=6478	White n=5585	Black n=278	Hispanic n=376	Other n=239	P value	Adjusted p value*
Age (years)	77 (71–82)	77 (72–82)	72 (66–78)	77 (71–82)	75 (68–82)	**<0.001**	**<0.001**
Sex, male	3781 (58)	3299 (59)	128 (46)	212 (56)	142 (59)	**<0.001**	**<0.001**
Median household income							
0–25th percentile	1311 (20)	1038 (19)	131 (47)	108 (29)	34 (14)	**<0.001**	**<0.001**
26–50th percentile	1679 (26)	1492 (27)	57 (21)	88 (23)	42 (18)		
51–75th percentile	1803 (28)	1572 (28)	54 (19)	108 (29)	69 (29)		
76–100th percentile	1685 (26)	1483 (27)	36 (13)	72 (19)	94 (39)		
Patient location							
Urban†	5480 (85)	4670 (84)	255 (92)	337 (90)	218 (91)	**<0.001**	**<0.001**
Rural	998 (15)	915 (16)	23 (8.3)	39 (10)	21 (8.8)		
Hospital teaching status and location							
Rural	112 (1.7)	112 (2.0)	<10 (0)	<10 (0)	<10 (0)	**<0.001**	**<0.001**
Urban non-teaching	561 (8.7)	496 (8.9)	18 (6.5)	32 (8.5)	15 (6.3)		
Urban teaching	5805 (90)	4977 (89)	260 (94)	344 (91)	224 (94)		
Hospital bed size							
Small	671 (10)	555 (9.9)	22 (7.9)	62 (16)	32 (13)	**0.002**	**<0.001**
Medium	1370 (21)	1190 (21)	60 (22)	69 (18)	51 (21)		
Large	4437 (68)	3840 (69)	196 (71)	245 (65)	156 (65)		
Primary payer*							
Medicare	5744 (89)	5013 (90)	224 (81)	310 (82)	197 (82)	**<0.001**	**<0.001**
Medicaid	75 (1.2)	37 (0.7)	14 (5.0)	15 (4.0)	<10 (3.8)		
Private insurance	529 (8.2)	432 (7.8)	28 (10)	42 (11)	27 (11)		
Other	118 (1.8)	91 (1.6)	12 (4.3)	9 (2.4)	<10 (2.5)		
Comorbidities							
Smoking	2262 (35)	1989 (36)	98 (35)	91 (24)	84 (35)	**<0.001**	**<0.001**
Dyslipidaemia	3883 (60)	3349 (60)	170 (61)	225 (60)	139 (58)	0.92	0.92
Renal	667 (10)	555 (10)	47 (17)	33 (9)	32 (13)	**<0.001**	**<0.001**
Previous CABG	977 (15)	864 (15)	21 (8)	63 (17)	29 (12)	**0.002**	**0.001**
Hypertension	5575 (86)	4771 (85)	263 (95)	337 (90)	204 (85)	**<0.001**	**<0.001**
Diabetes mellitus	2242 (35)	1871 (34)	115 (41)	162 (43)	94 (39)	**<0.001**	**<0.001**
Obesity	1085 (17)	933 (17)	63 (23)	62 (16)	27 (11)	**0.01**	**0.01**
Congestive heart failure	2488 (38)	2110 (38)	141 (51)	144 (38)	93 (39)	**<0.001**	**<0.001**
Myocardial infarction	821 (13)	706 (13)	37 (13)	49 (13)	29 (12)	0.98	0.98
Peripheral vascular disease	685 (11)	601 (11)	30 (11)	31 (8)	23 (10)	0.46	0.46
Cerebrovascular disease	1859 (29)	1566 (28)	95 (34)	111 (30)	87 (36)	**0.01**	**0.01**
Valvular disease	1365 (21)	1208 (22)	63 (23)	51 (14)	43 (18)	**0.001**	**0.001**
COPD	1419 (22)	1223 (22)	86 (31)	75 (20)	35 (15)	**<0.001**	**<0.001**
Rheumatic disease	188 (2.9)	160 (2.9)	11 (4)	12 (3.2)	<10 (2.1)	0.59	0.62
Liver disease	173 (2.7)	134 (2.4)	<10 (3.2)	20 (5.3)	10 (4.2)	**0.004**	**0.003**
Hypothyroidism	1100 (17)	977 (17)	29 (10)	65 (17)	29 (12)	**0.004**	**0.004**
Cancer	149 (2.3)	126 (2.3)	<10 (2.9)	<10 (2.4)	<10 (2.5)	0.83	0.91
Anaemia	496 (7.7)	412 (7.4)	38 (14)	30 (8.0)	16 (6.7)	**0.004**	**0.002**
Depression	484 (7.5)	429 (7.7)	19 (6.8)	27 (7.2)	<10 (3.8)	0.15	0.15
Charlson comorbidity index	2 (1–3)	2 (1–3)	3 (1–4)	2 (1–3)	2 (1–3.5)	**<0.001**	**<0.001**
Elixhauser comorbidity score	8 (5–13)	8 (5–13)	12 (6–17)	9 (5–13.25)	10 (5–14)	**<0.001**	**<0.001**
CHA_2DS_2-VASc	4 (3–5)	4 (3–5)	4 (3–5.75)	4 (3–5)	4 (3–5)	**0.03**	**0.03**
≥2 (High)	6333 (97.8)	5463 (97.8)	275 (98.9)	367 (97.6)	228 (95.4)	0.07	0.18
Year of procedure							
2015 (October–December)	111 (1.7)	91 (1.6)	<10 (1.8)	<10 (2.4)	<10 (2.5)	**<0.001**	**<0.001**
2016 (January–December)	960 (15)	838 (15)	33 (12)	34 (9)	55 (23)		
2017 (January–December)	2054 (32)	1770 (32)	89 (32)	122 (32)	73 (31)		
2018 (January–December)	3353 (52)	2886 (52)	151 (54)	211 (56)	105 (44)		
Length of stay (days, range)	0–35	0–35	0–26	0–25	0–11	–	–
Length of stay (days, median)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	**<0.001**	**<0.001**
≤1 day	5555 (86)	4840 (87)	210 (76)	310 (82)	195 (82)	**<0.001**	**<0.001**
>1 day	923 (14)	745 (13)	68 (24)	66 (18)	44 (18)		
Total index cost (US$)†	24 434 (18 648–30 210)	24 327 (18 529–30 201)	25 643 (18 993–29 737)	23 914 (19 755–29 732)	26 497 (20 608–31 355)	**0.05**	**0.04**
Deaths	<10 (0.1)	<10 (0.2)	<10 (0)	<10 (0)	<10 (0)	>0.99	0.69

Values are expressed as median (IQR) or counts (%). Exact counts for variables with <10 patients are not detailed as per the Healthcare Cost and Utilization Project data use agreement.
Bold type indicates significant p values (<0.05).
*Adjusted p values for each variable were computed from adjusting sampling design by discharge-level weights, cluster and strata.
†Total cost was missing 0.6%.
‡Primary payer was missing in 0.1%.
§Urban location was defined as counties in metro areas of >50 000 population.
CABG, coronary artery bypass surgery; CHA_2DS_2-VASc, congestive heart failure, hypertension, age ≥75 years, diabetes, prior stroke or transient ischaemic attack, vascular disease (including previous myocardial infarction), age 65–74 years, sex category; COPD, chronic obstructive pulmonary disease.

Table 2 Baseline characteristics of the study population stratified by median household income

Patient characteristics	All n=6478	Quartile 1 n=1311	Quartile 2 n=1679	Quartile 3 n=1803	Quartile 4 n=1685	P value	Adjusted p value*
Age (years)	77 (71–82)	76 (71–81)	77 (71–82)	77 (71–82)	77 (71–82)	**0.004**	**0.003**
Sex, male	3781 (58)	713 (54)	973 (58)	1052 (58)	1043 (62)	**<0.001**	**<0.001**
Race							
White	5585 (86)	1038 (79)	1492 (89)	1572 (87)	1483 (88)	**<0.001**	**<0.001**
Black	278 (4.3)	131 (10)	57 (3.4)	54 (3.0)	36 (2.1)		
Hispanic	376 (5.8)	108 (8.2)	88 (5.2)	108 (6.0)	72 (4.3)		
Other	239 (3.7)	34 (2.6)	42 (2.5)	69 (3.8)	94 (5.6)		
Patient location							
Urban†	5480 (85)	831 (63)	1280 (76)	1694 (94)	1675 (99)	**<0.001**	**<0.001**
Rural	998 (15)	480 (37)	399 (24)	109 (6.0)	10 (0.6)		
Hospital teaching status and location							
Rural	112 (1.7)	38 (2.9)	56 (3.3)	18 (1.0)	<10 (0)	**<0.001**	**<0.001**
Urban non-teaching	561 (8.7)	108 (8.2)	137 (8.2)	149 (8.3)	167 (9.9)		
Urban teaching	5805 (90)	1165 (89)	1486 (89)	1636 (91)	1518 (90)		
Hospital bed size							
Small	671 (10)	140 (11)	167 (9.9)	204 (11)	160 (9.5)	0.32	0.28
Medium	1370 (21)	286 (22)	374 (22)	372 (21)	338 (20)		
Large	4437 (68)	885 (68)	1138 (68)	1227 (68)	1187 (70)		
Primary payer*							
Medicare	5744 (89)	1155 (88)	1497 (89)	1619 (90)	1473 (87)	**0.02**	0.05
Medicaid	75 (1.2)	25 (1.9)	21 (1.3)	13 (0.7)	16 (1.0)		
Private insurance	529 (8.2)	98 (7.5)	127 (7.6)	145 (8.1)	159 (9.4)		
Other	118 (1.8)	29 (2.2)	29 (1.7)	24 (1.3)	36 (2.1)		
Comorbidities							
Smoking	2262 (35)	464 (35)	587 (35)	618 (34)	593 (35)	0.92	0.92
Dyslipidaemia	3883 (60)	775 (59)	1024 (61)	1056 (59)	1028 (61)	0.34	0.34
Renal disease	667 (10)	139 (11)	161 (10)	203 (11)	164 (10)	0.28	0.28
Previous CABG	977 (15)	192 (15)	256 (15)	279 (15)	250 (15)	0.91	0.91
Hypertension	5575 (86)	1153 (88)	1444 (86)	1532 (85)	1446 (86)	0.12	0.12
Diabetes mellitus	2242 (35)	492 (38)	611 (36)	604 (33)	535 (32)	**0.002**	**0.002**
Obesity	1085 (17)	239 (18)	293 (17)	289 (16)	264 (16)	0.19	0.19
Congestive heart failure	2488 (38)	541 (41)	651 (39)	706 (39)	590 (35)	**0.004**	**0.004**
Myocardial infarction	821 (13)	182 (14)	227 (14)	229 (13)	183 (11)	0.05	0.05
Peripheral vascular disease	685 (11)	139 (11)	190 (11)	202 (11)	154 (9.1)	0.14	0.14
Cerebrovascular disease	1859 (29)	390 (30)	455 (27)	520 (29)	494 (29)	0.37	0.37
Valvular disease	1365 (21)	281 (21)	354 (21)	355 (20)	375 (22)	0.31	0.31
Dementia	177 (2.7)	37 (2.8)	49 (2.9)	36 (2)	55 (3.3)	0.13	0.13
COPD	1419 (22)	321 (24)	406 (24)	382 (21)	310 (18)	**<0.001**	**<0.001**
Rheumatic disease	188 (2.9)	42 (3.2)	43 (2.6)	58 (3.2)	45 (2.7)	0.56	0.56
Liver disease	173 (2.7)	41 (3.1)	46 (2.7)	49 (2.7)	37 (2.2)	0.46	0.46
Hypothyroidism	1100 (17)	222 (17)	277 (16)	340 (19)	261 (15)	0.06	0.06
Cancer	149 (2.3)	22 (1.7)	42 (2.5)	49 (2.7)	36 (2.1)	0.24	0.24
Anaemia	496 (7.7)	103 (7.9)	136 (8.1)	132 (7.3)	125 (7.4)	0.81	0.81
Depression	484 (7.5)	79 (6)	131 (7.8)	166 (9.2)	108 (6.4)	**0.002**	**0.002**
Charlson comorbidity index	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	1 (1–3)	**<0.001**	**<0.001**
Elixhauser comorbidity score	8 (5–13)	10 (5–14)	9 (5–13)	9 (5–13)	8 (5–12)	**0.002**	**0.002**
CHA_2DS_2-VASc	4 (3–5)	4 (3–5)	4 (3–5)	4 (3–5)	4 (3–5)	**0.01**	**0.01**
≥2 (high)	6333 (98)	1279 (98)	1641 (98)	1766 (98)	1647 (98)	0.91	0.19
Year of procedure							
2015 (October–December)	111 (1.7)	20 (1.5)	25 (1.5)	26 (1.4)	40 (2.4)	**<0.001**	**<0.001**
2016 (January–December)	960 (15)	172 (13)	222 (13)	265 (15)	301 (18)		
2017 (January–December)	2054 (32)	431 (33)	521 (31)	594 (33)	508 (30)		
2018 (January–December)	3353 (52)	688 (52)	911 (54)	918 (51)	836 (50)		
Length of stay (days, range)	0–35	0–26	0–35	0–27	0–21	–	–
Length of stay (days, median)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	**0.01**	**0.01**
≤1 day	5555 (86)	1099 (84)	1450 (86)	1534 (85)	1472 (87)	**0.03**	**0.03**
>1 day	923 (14)	212 (16)	229 (14)	269 (15)	213 (13)		

Continued

Table 2 Continued

Patient characteristics	All n=6478	Quartile 1 n=1311	Quartile 2 n=1679	Quartile 3 n=1803	Quartile 4 n=1685	P value	Adjusted p value*
Total index cost (US$)†	24 434 (18 648–30 210)	23 608 (17 914–28 982)	23 983 (18 216–29 896)	25 054 (19 449–30 677)	24 920 (19 582–31 200)	**<0.001**	**<0.001**
Deaths	<10 (0.2)	<10 (0.3)	<10 (0.3)	<10 (0.1)	0 (0)	0.31	0.40

Values are expressed as median (IQR) or counts (%). Exact counts for variables with <10 patients are not detailed as per the Healthcare Cost and Utilization Project data use agreement.
Bold type indicates significant p values (<0.05).
*Adjusted p values for each variable were computed from adjusting sampling design by discharge-level weights, cluster and strata.
†Total cost was missing 0.6%.
‡Primary payer was missing in 0.1%.
§Urban location was defined as counties in metro areas of >50 000 population.
CABG, coronary artery bypass surgery; CHA_2DS_2-VASc, congestive heart failure, hypertension, age ≥75 years, diabetes, prior stroke or transient ischaemic attack, vascular disease (including previous myocardial infarction), age 65–74 years, sex category; COPD, chronic obstructive pulmonary disease.

adjustments. Results are presented as OR with 95% CI. All p values are two sided with a significance threshold of <0.05. Statistical analyses were performed using R V.3.6.3.[16]

Patient and public involvement

There were no patients or the public involved around the research question or conception and design of the study. Because of the nature of the study, patients or public were not involved in any recruitment or conduction of the study. No patients or public were involved in measuring the outcomes, nor were asked to provide interpretations of the findings or writing of the results.

RESULTS

Study population

A total of 6779 unweighted hospitalisations were identified; of these, 204 (3.0%) were excluded due to missing racial/ethnic group data, and 93 (1.4%) were excluded due to missing income quartile data and 4 (0.05%) for missing both variables, leaving 6478 patients for the final analysis. In this final cohort, 3781 (58%) were men and 5585 (86%) were of white ethnicity. Black, Hispanic and patients of 'other' race/ethnicity each comprised less than 5% of the total cohort. The number of LAAC procedures performed on patients of each racial/ethnic group was divided by the total population of individuals over the age 65 years of each ethnicity in the USA, after adjustment for sampling design and discharge weights.[17] The estimated number of LAAC procedures was 69.2/100 000 for white individuals, as compared with 29.5/100 000 for blacks, 47.2/100 000 for Hispanics and 40.7/100 000 for individuals of 'other' race/ethnicity.

A quarterly analysis was conducted to compare the number of procedures performed on patients of white and non-white race/ethnicity over time (figure 1). Based on the Cochrane-Armitage trend test, there were no statistical differences in the proportion of LAAC performed on patients of white versus non-white race/ethnicity (P_{trend}=0.95). In addition, no statistical differences were observed in procedures performed among individuals of white, black and Hispanic race/ethnicity over time (p=0.27 for whites vs blacks, and p=0.06 for whites vs Hispanics). Figure 1 also displays the changes in the distribution of LAAC procedures performed in patients living in urban versus rural regions, importantly, there was a significant increase (p=0.015) over time in the proportion of patients from rural regions receiving LAAC.

Baseline characteristics stratified by race and zip code income quartile are presented in tables 1 and 2, respectively. Several important differences were found between the racial/ethnic groups. A significant difference was found in the median age

Table 3 In-hospital major adverse events

Stratified by race/ethnic groups							
In-hospital major adverse events	**All n=6478**	**White n=5585**	**Black n=278**	**Hispanic n=376**	**Other n=239**	**P value**	**Adjusted p value***
Overall major adverse events†	323 (5.0)	258 (4.6)	26 (9.4)	27 (7.2)	12 (5.0)	**<0.001**	**<0.001**
Bleeding complications	37 (0.6)	30 (0.5)	<10 (0.4)	<10 (1.1)	<10 (0.8)	0.37	0.52
Cardiac complications	132 (2.0)	113 (2.0)	<10 (2.2)	<10 (1.6)	<10 (2.9)	0.67	0.72
Vascular complications	27 (0.4)	25 (0.4)	<10 (0.4)	<10 (0.3)	<10 (0)	0.95	0.72
Stroke/TIA	21 (0.3)	19 (0.3)	<10 (0.4)	<10 (0.3)	<10 (0)	0.94	0.83
Acute kidney injury	151 (2.3)	113 (2.0)	18 (6.5)	15 (4.0)	<10 (2.1)	**<0.001**	**<0.001**
Stratified by income quartiles							
In-hospital major adverse events	**All n=6478**	**Quartile 1 n=1311**	**Quartile 2 n=1679**	**Quartile 3 n=1803**	**Quartile 4 n=1685**	**P value**	**Adjusted p value**
Overall major adverse events†	323 (5.0)	64 (4.9)	85 (5.1)	95 (5.3)	79 (4.7)	0.88	0.88
Bleeding complications	37 (0.6)	<10 (0.5)	12 (0.7)	13 (0.7)	<10 (0.3)	0.29	0.31
Cardiac complications	132 (2.0)	22 (1.7)	38 (2.3)	41 (2.3)	31 (1.8)	0.55	0.55
Vascular complications	27 (0.4)	<10 (0.5)	10 (0.6)	<10 (0.2)	<10 (0.3)	0.37	0.39
Stroke/TIA	21 (0.3)	<10 (0.3)	<10 (0.4)	<10 (0.3)	<10 (0.3)	0.92	0.89
Acute kidney injury	151 (2.3)	34 (2.6)	31 (1.8)	45 (2.5)	41 (2.4)	0.49	0.49

Values are expressed as counts (%). Exact counts for variables with <10 patients are not detailed as per the Healthcare Cost and Utilization Project data use agreement.
Bold type indicates significant p values (<0.05).
*Adjusted p values for each variable were computed from adjusting sampling design by discharge-level weights, cluster and strata.
†Numbers/percentages may not add up since several patients experienced more than one complication.
TIA, transient ischaemic attack.

of patients of each racial/ethnic group ($p<0.001$). In particular, the median age of blacks was 5 years younger than that of white patients (77 (72–82) vs 72 (66–78) years, $p<0.001$ using Mann-Whitney U test with Bonferroni correction). Around 55% of the patients lived in neighbourhoods in the upper half of household incomes, with 1083 (28%) and 1685 (26%) coming from the third and fourth quartiles, respectively, and 37% of patients living in zip code median income quartile 1 lived in a rural region (table 2). Most (90%) of the LAAC procedures were performed in urban-teaching hospitals. The primary payer was significantly different among racial/ethnic groups ($p<0.001$); interestingly, private insurance was found more frequently among minorities (table 1).

There were significant differences in median CCI ($p<0.001$), ECS ($p<0.001$) and CHA_2DS_2-VASc scores ($p=0.03$) of each racial/ethnic group. These differences were driven by differences in several comorbidities, including renal disease, hypertension, congestive heart failure and anaemia, with black patients having significantly higher prevalence of each of these comorbidities ($p<0.05$ for all). Median LOS differed between groups

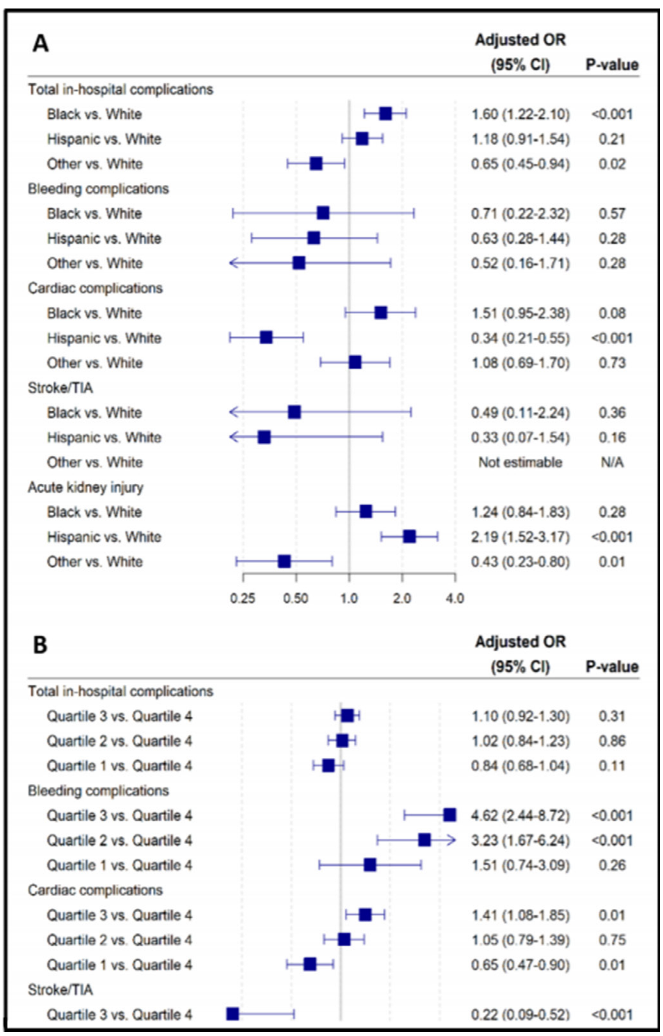

Figure 2 Forest plot showing multilevel multivariable regression analysis for in-hospital major adverse events adjusted by age, sex, relevant comorbidities, and racial/ethnic and neighbourhood income quartiles. (A) Stratified by racial/ethnic groups and adjusted by zip code median household income quartiles. (B) Stratified by zip code median household income quartiles and adjusted by racial/ethnic groups. TIA, transient ischaemic attack.

($p<0.001$) and hence index hospitalisation costs also tend to differ ($p=0.05$), with blacks having the highest median costs compared with the other races (table 1).

Significant differences were also found between the patients in each zip code household income quartile. Among these, the median CCI ($p<0.001$), ECS ($p=0.002$) and CHA_2DS_2-VASc ($p=0.01$) scores differed between income quartiles. Median LOS ($p=0.01$) was also significantly different, and index hospitalisation costs increased significantly as neighbourhood incomes increased from quartile 1 to quartile 4 ($23 608 vs $23 983 vs $25 054 vs $24 920, $p<0.001$) (table 2).

In-hospital complications

The primary composite outcome of in-hospital major adverse events occurred in 323 (5.0%) patients and differed significantly between racial/ethnic groups (4.6% in whites vs 9.4% in blacks vs 7.2% in Hispanics, $p<0.001$) but not zip code income quartiles ($p=0.88$). In-hospital complication rates stratified by race/ethnicity and neighbourhood income quartiles are shown in table 3. Notably, the occurrence of stroke/TIA and death were low, with incidences of 0.3% and 0.2%, respectively. Of the individual complications, only AKI differed significantly ($p<0.001$), while there were no significant differences within the income quartile analysis.

After multilevel modelling with adjustment for relevant comorbidities and neighbourhood income quartiles (figure 2A), the overall rate of in-hospital major adverse events was higher in black patients as compared with whites (OR: 1.60, 95% CI 1.22 to 2.10, $p<0.001$) while lower in patients of ‘Other’ race/ethnicity (OR: 0.65, 95% CI 0.45 to 0.94, $p=0.02$). Among the individual in-hospital complications, AKI was more commonly observed among Hispanics (OR: 2.19, 95% CI 1.52 to 3.17, $p<0.001$), while the rate of cardiac complications was lower (OR: 0.34, 95% CI 0.21 to 0.55, $p<0.001$). No statistical differences were found among the individual components of the composite endpoint between white and black patients.

No statistical differences were found in adjusted overall in-hospital complication rates between neighbourhood income quartiles (figure 2B). However, among the individual components of the composite endpoint, the rates of cardiac complications were lower in quartile 1 as compared with quartile 4 (OR: 0.65, 95% CI 0.47 to 0.90, $p=0.01$), and the rates of bleeding complications were higher in quartile 3 ($p<0.001$) and quartile 2 ($p<0.001$). An ad hoc sensitivity analysis was performed to determine the effect that adjustment by racial/ethnic and neighbourhood income quartile had on their corresponding model. After removing these variables and adjusting in-hospital outcomes only by age, sex and relevant comorbidities, no differences were found in the significance of the racial/ethnic group or income quartile stratified outcomes (figure 3). Post hoc sensitivity analysis for multilevel multivariable models adjusted by comorbidities with univariable p value <0.2 was performed, and no differences in the significance of any complication rate was found (online supplemental table 3).

The results of the multilevel multivariable model assessing the impact of preprocedural comorbidities on total complication rates are displayed in figure 4. After adjusting for race/ethnicity, the presence of preprocedural anaemia had the largest impact on the risk of in-hospital complications (OR: 2.24, 95% CI 1.87 to 2.69, $p<0.001$), followed by renal disease (OR: 1.78, 95% CI 1.64 to 1.94) (figure 4A). Sensitivity analysis with adjustment by race/ethnicity alone

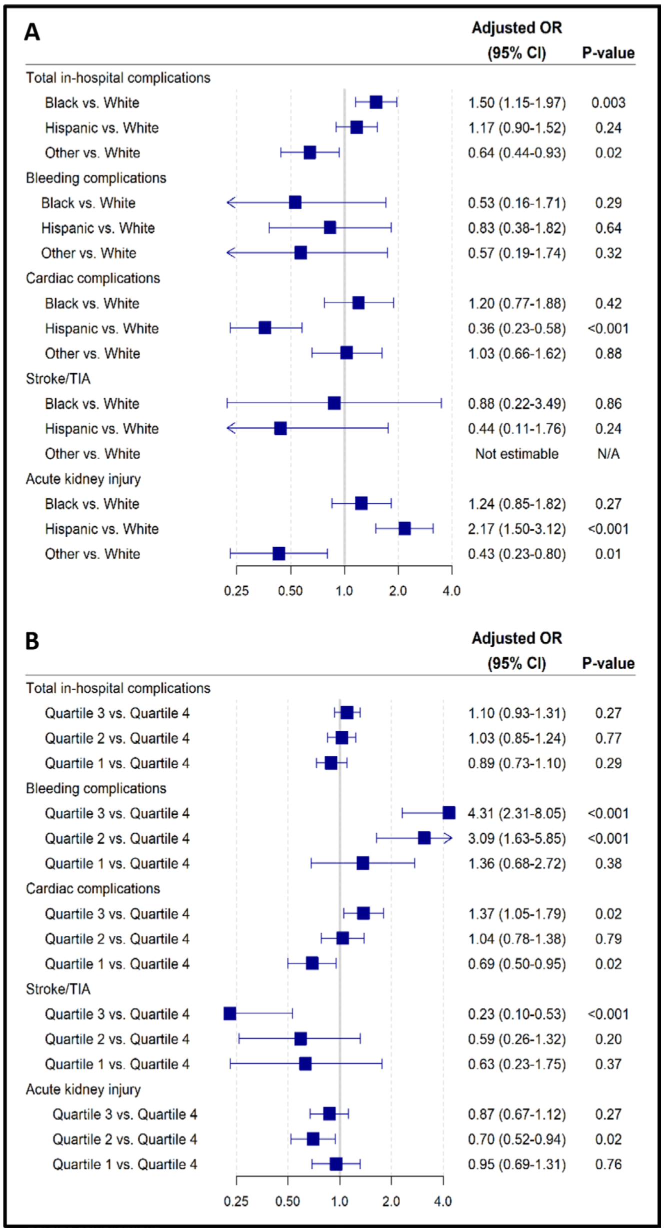

Figure 3 Forest plots showing a sensitivity analysis to determine the effect that adjustment by racial/ethnic and neighbourhood income quartiles had on their corresponding model for in-hospital major adverse events. Multilevel multivariable regression analysis adjusted by age, sex and relevant comorbidities. (A) Stratified by racial/ethnic groups. (B) Stratified by zip code median household income quartiles. TIA, transient ischaemic attack.

(figure 4B) and neighbourhood income quartiles alone (figure 4B) yielded almost identical results.

DISCUSSION

In this cohort-based observational study of 6478 hospitalisations for LAAC, 86% were of white race/ethnicity and about half lived in neighbourhoods below the median income level. The primary outcome of overall in-hospital major adverse events occurred in 5% of patients, and an analysis of the distribution of these complications yielded several important results. First, black patients tended to have higher preprocedural burden of comorbidities compared with other races. Second, black patients had significantly higher complication rates as compared with whites, both, before and after adjustment for relevant clinical variables. Third, the presence of baseline congestive heart failure, chronic kidney disease and anaemia were strongly associated with in-hospital complications in the overall cohort. Finally, low socioeconomic status, as measured by median neighbourhood income, was not associated with higher rates of in-hospital complication following LAAC. Figure 5 displays a summary of these findings.

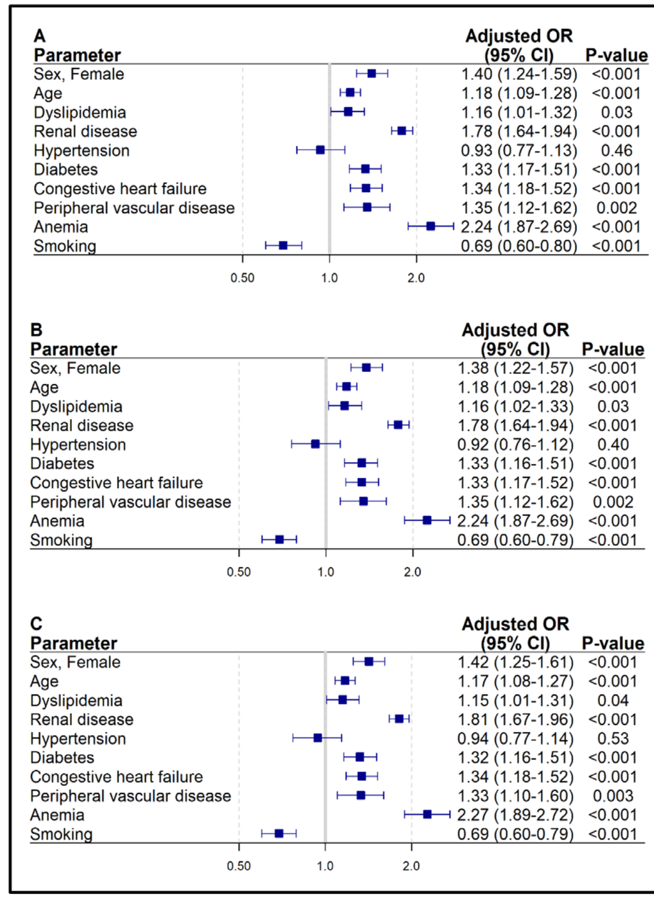

Figure 4 Forest plot showing multilevel multivariable regression analyses for comorbidities associated with in-hospital major adverse events. (A) Adjusted by racial/ethnic groups and median household income quartiles. (B) Sensitivity analysis adjusted by racial/ethnic groups and (C) by median household income quartiles.

Disparities in LAAC

An important finding of this study is that black and Hispanic patients were under-represented compared with the proportion of US individuals that are aged over 65 years old. Indeed, a report from the US Department of Health and Human Services showed that in 2018, 23% of individuals aged 65 years and older were part of a racial/ethnic minority, among those, blacks and Hispanics accounted for 12% and 7%, respectively.[17] Therefore, cosidering a population of US individuals aged 65 years and older, the number of LAAC procedures performed in white patients was 2.3 times that of blacks and 1.5 times that of Hispanics.

Racial disparities in the utilisation of other cardiac procedures, including transcatheter aortic valve implantation, have previously been documented.[18] Our results indicate that disparities exist to a similar extent for LAAC, and there are likely multiple explanations for these differences. On one

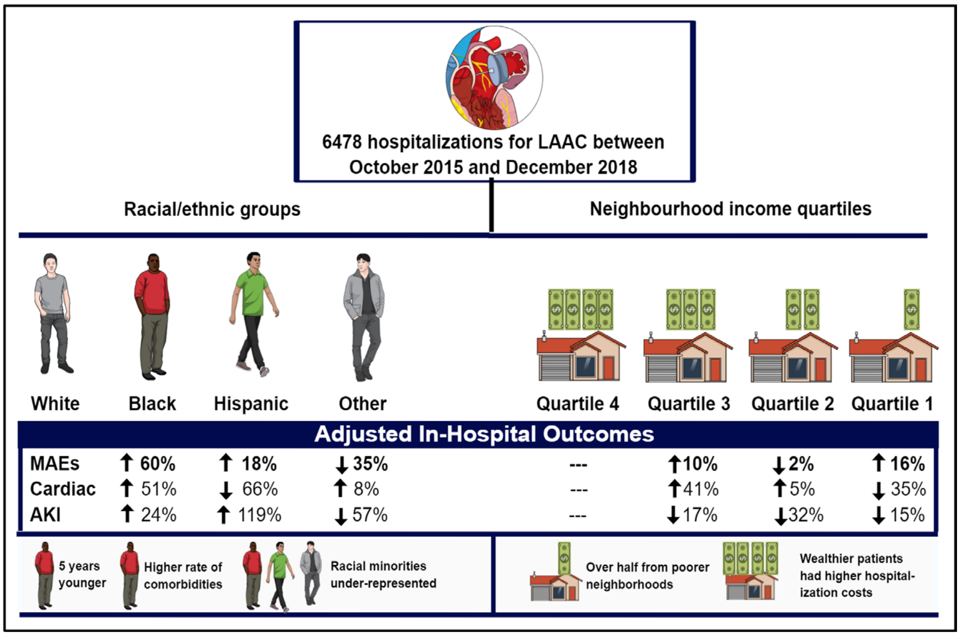

Figure 5 Infographic summarising major findings. White race/ethnicity and zip code median income quartile 4 were the comparator groups. Icons of men were chosen for each race/ethnic group for simplicity but do not imply a sex-specific relationship with outcomes. AKI, acute kidney injury; LAAC, left atrial appendage closure; MAEs, major adverse events.

hand, it is known that the incidence of AF is lower in black and Hispanic individuals as compared with whites counterparts.[19 20] However, previous studies have also shown that AF management and anticoagulation among racial minorities are less likely to follow guideline-directed medical therapy, and lower LAAC rates could be an extension of these disparities.[4 21] In this regard, Essien *et al*[22] assessed whether contraindications to oral anticoagulation differ by racial group and found no significant differences, suggesting that the proportion of patients with AF that would qualify for LAAC should be broadly similar across racial groups. Moreover, the use of new technologies tends to occur in large university hospital centres located in urban areas, which may have more diverse populations compared with smaller rural hospitals. Notably, another important finding of this study is the increased proportion of individuals located in rural regions, highlighting an improvement in access to LAAC over the study period.

Socioeconomic status is often related to racial/ethnic disparities. In fact, Sleder *et al*[23] showed that even in an urban academic medical centre, patients of lower income status and black race/ethnicity were less likely to undergo transcatheter aortic valve implantation, and this gap remained after adjusting for age and comorbidities. The authors also found that black patients with severe aortic stenosis often decline aortic valve replacement when recommended,[23] raising concerns about historical discrimination, trust and the delivery of care.[23–26]

Our study also indicates that black patients receiving LAAC were over 5 years younger than those in other racial/ethnic groups. However, despite their younger age, black patients still presented with a higher burden of comorbidities, and this is in line with previous data showing that black patients undergoing LAAC have higher ECS and hospitalisation costs.[5] As the number of black and Hispanic patients undergoing LAAC increased over time, future research may be able to confirm that this higher burden of comorbidities is correlated with significant impact on postprocedural outcomes.

In contrast to this body of research about racial disparities, less is known about socioeconomic disparities in AF and transcatheter-based cardiac interventions. A case–control study with 201 patients demonstrated that patients undergoing LAAC were of higher income level than those who did not,[27] but no previous studies have analysed the effect of socioeconomic status on LAAC outcomes. Our study shows no impact on neighbourhood income on any postprocedural outcomes, but further research is likely needed to assess the impact of other indicators of socioeconomic status such as education and personal incomes.

Limitations

This paper presents an observational, retrospective analysis and relies on the accuracy of the ICD-10 codes in the NIS database for its findings. Administrative errors in coding patient comorbidities and in-hospital complications may therefore be a source of error. We restricted the strategy of using solely postprocedural bleeding codes, which reduced the risk of false positives, yet certain events may not have been accurately tracked. A number of potential confounders, including information on vascular access points, arterial access, operator (electrophysiologist vs interventional cardiologist), preprocedural anticoagulation, were not available and thus could not be included in the adjustments and may represent a source of unmeasured bias. The lack of granularity of certain variables precluded the calculation of preprocedural bleeding risk such as the HAS-BLED (hypertension, abnormal renal/liver function, stroke, bleeding history or predisposition, labile INR, elderly and drugs/alcohol concomitantly) score. Medications at hospital discharge (ie, antiplatelets and anticoagulants with or without concomitant antiplatelets) were not available. Socioeconomical disparities may have played a role on postprocedural management. Lastly, this study is limited to in-hospital outcomes where we observed a relatively short LOS (median 1 day); hence, complications at 30 days and need for readmission are potentially important outcomes that were not captured in this study.

CONCLUSION

In this study assessing racial/ethnic disparities in LAAC outcomes, aged-based race/ethnicity minorities were under-represented, and this disparity was more marked among black patients. Moreover, about half of the population live in neighbourhoods below the median income level. Black patients were younger, had the higher comorbidity burden and experienced a higher rate of postprocedural adverse events as compared with whites patients. Low socioeconomic status was not associated with higher rates of in-hospital complications following LAAC.

Key messages

What is already known on this subject?

- ► Inequalities in access, management and outcomes among patients of various races/ethnicities and socioeconomic status has been well documented in various domains of cardiology.
- ► Previous research has shown that both racial and socioeconomic disparities exist in atrial fibrillation management and transcatheter aortic valve implantation.

What might this study add?

- ► This retrospective cohort study of US hospitalisations found that patients of racial/ethnic minority groups, most notably blacks, were under-represented recipients of left atrial appendage closure (LAAC) procedures as compared with white patients.
- ► Black patients were about 5 years younger but presented with higher burden of comorbidities.
- ► Adjusted total in-hospital complication rates were higher in patients of black race/ethnicity as compared with whites.

How might this impact on clinical practice?

- ► These findings contribute with the understanding of how outcomes differ among patients of various racial/ethnic groups and socioeconomic status.
- ► Further research is needed to understand the causes behind these disparities, the reasons why racial/ethnic minority groups make up an under-represented portion of patients receiving LAAC in the US and whether longer term differences in outcomes and readmission rates are present.

Author affiliations
[1]Schulich School of Medicine and Dentistry, Western University, London, Ontario, Canada
[2]Department of Epidemiology and Biostatistics, Schulich School of Medicine and Dentistry, Western University, London, Ontario, Canada
[3]Division of Cardiology, Weill Cornell Medicine-Qatar, Doha, Qatar
[4]Division of Cardiology, Baylor College of Medicine and Michael E DeBakey Veterans Affairs Medical Center, Houston, Texas, USA
[5]Center for Structural Heart Disease, Henry Ford Health System, Detroit, Michigan, USA
[6]Department of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota, USA
[7]The University of Arizona College of Medicine – Phoenix, Phoenix, Arizona, USA
[8]Department of Interventional Cardiology, Wayne State University, Detroit, Michigan, USA
[9]Department of Clinical Neurological Sciences, Schulich School of Medicine and Dentistry, London, Ontario, Canada
[10]London Health Sciences Centre, London, Ontario, Canada
[11]Keele Cardiovascular Research Group, Centre for Prognosis Research, Institute of Primary Care and Health Sciences, Keele University, Stoke-on-Trent, Stoke, UK

Twitter Islam Y Elgendy @islamelgendy83, Luciano A Sposato @SposatoL, Mamas A Mamas @MMamas1973 and Rodrigo Bagur @RodrigoBagur

Acknowledgements The authors would like to thank the Healthcare Cost and Utilization Project (HCUP) and the HCUP Data Partners for providing the data used in the analysis.

Contributors RS and RB conceived and designed the study. RS, Y-HC and RB analysed, interpreted the data and drafted the first version of the manuscript. All authors have interpreted the data, critically revised, provided intellectual contributions and approved the final version of the manuscript. RB is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests DH is on the Advisory Board for Boston Scientific, unpaid.

Patient consent for publication Not required.

Ethics approval Institutional review board and ethics committee approval was obtained from The Western University Health Science Research Ethics Board.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

ORCID iDs
Robbie Sparrow http://orcid.org/0000-0001-5775-7299
Islam Y Elgendy http://orcid.org/0000-0001-9853-7591
Luciano A Sposato http://orcid.org/0000-0001-6425-9343
Mamas A Mamas http://orcid.org/0000-0001-9241-8890
Rodrigo Bagur http://orcid.org/0000-0003-1888-9429

REFERENCES

1 Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham study. *Stroke* 1991;22:983–8.
2 Holmes DR, Doshi SK, Kar S, *et al*. Left atrial appendage closure as an alternative to warfarin for stroke prevention in atrial fibrillation: a patient-level meta-analysis. *J Am Coll Cardiol* 2015;65:2614–23.
3 Reddy VY, Doshi SK, Kar S, *et al*. 5-year outcomes after left atrial appendage closure: from the prevail and protect AF trials. *J Am Coll Cardiol* 2017;70:2964–75.
4 Ugowe FE, Jackson LR, Thomas KL. Racial and ethnic differences in the prevalence, management, and outcomes in patients with atrial fibrillation: a systematic review. *Heart Rhythm* 2018;15:1337–45.
5 Alkhouli M, Alqahtani F, Holmes DR, *et al*. Racial disparities in the utilization and outcomes of structural heart disease interventions in the United States. *J Am Heart Assoc* 2019;8:e012125.
6 Overview of the National (Nationwide) Inpatient Sample (NIS). Agency for healthcare research and quality, 2019. Available: https://www.hcup-us.ahrq.gov/nisoverview.jsp [Accessed 9 Mar 2020].
7 Lip GYH, Frison L, Halperin JL, *et al*. Identifying patients at high risk for stroke despite anticoagulation: a comparison of contemporary stroke risk stratification schemes in an anticoagulated atrial fibrillation cohort. *Stroke* 2010;41:2731–8.
8 Borovac JA, Kwok CS, Mohamed MO, *et al*. The predictive value of CHA_2DS_2-VASc score on in-hospital death and adverse periprocedural events among patients with the acute coronary syndrome and atrial fibrillation who undergo percutaneous coronary intervention: a 10-year National Inpatient Sample (NIS) analysis. *Cardiovasc Revasc Med* 2020. doi:10.1016/j.carrev.2020.08.003. [Epub ahead of print: 07 Aug 2020].
9 Charlson ME, Pompei P, Ales KL, *et al*. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
10 Elixhauser A, Steiner C, Harris DR, *et al*. Comorbidity measures for use with administrative data. *Med Care* 1998;36:8–27.
11 van Walraven C, Austin PC, Jennings A, *et al*. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. *Med Care* 2009;47:626–33.

12 Bagur R, Martin GP, Nombela-Franco L, *et al*. Association of comorbid burden with clinical outcomes after transcatheter aortic valve implantation. *Heart* 2018;104:2058–66.
13 Kwok CS, Walsh MN, Volgman A, *et al*. Discharge against medical advice after hospitalisation for acute myocardial infarction. *Heart* 2019;105:315–21.
14 Kwok CS, Lundberg G, Al-Faleh H, *et al*. Relation of frailty to outcomes in patients with acute coronary syndromes. *Am J Cardiol* 2019;124:1002–11.
15 Khera R, Angraal S, Couch T, *et al*. Adherence to methodological standards in research using the National inpatient sample. *JAMA* 2017;318:2011–8.
16 R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R foundation for statistical computing, 2020. Available: https://www.R-project.org/
17 Living AfC. 2019 profile of older Americans. U.S. department of health and human services 2020.
18 Alkhouli M, Holmes DR, Carroll JD, *et al*. Racial disparities in the utilization and outcomes of TAVR: TVT Registry report. *JACC Cardiovasc Interv* 2019;12:936–48.
19 Dewland TA, Olgin JE, Vittinghoff E, *et al*. Incident atrial fibrillation among Asians, Hispanics, blacks, and whites. *Circulation* 2013;128:2470–7.
20 Mou L, Norby FL, Chen LY, *et al*. Lifetime risk of atrial fibrillation by race and socioeconomic status: ARIC study (atherosclerosis risk in communities). *Circ Arrhythm Electrophysiol* 2018;11:e006350.
21 Golwala H, Jackson LR, Simon DN, *et al*. Racial/Ethnic differences in atrial fibrillation symptoms, treatment patterns, and outcomes: insights from outcomes Registry for better informed treatment for atrial fibrillation registry. *Am Heart J* 2016;174:29–36.
22 Essien UR, Holmes DN, Jackson LR, *et al*. Association of Race/Ethnicity with oral anticoagulant use in patients with atrial fibrillation: findings from the outcomes Registry for better informed treatment of atrial fibrillation II. *JAMA Cardiol* 2018;3:1174–82.
23 Sleder A, Tackett S, Cerasale M, *et al*. Socioeconomic and racial disparities: a case-control study of patients receiving transcatheter aortic valve replacement for severe aortic stenosis. *J Racial Ethn Health Disparities* 2017;4:1189–94.
24 Yeung M, Kerrigan J, Sodhi S, *et al*. Racial differences in rates of aortic valve replacement in patients with severe aortic stenosis. *Am J Cardiol* 2013;112:991–5.
25 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.
26 Lindman BR, Arnold SV, Bagur R, *et al*. Priorities for patient-centered research in valvular heart disease: a report from the National heart, lung, and blood Institute Working group. *J Am Heart Assoc* 2020;9:e015975.
27 Kupsky DF, Wang DD, Eng M, *et al*. Socioeconomic disparities in access for Watchman device insertion in patients with atrial fibrillation and at elevated risk of bleeding. *Structural Heart* 2019;3:144–9.