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Patterns and gaps in guideline-directed statin use for atherosclerotic cardiovascular disease by race and ethnicity

Ashish Sarraju [a], Xiaowei Yan [b], Qiwen Huang [b], Ramzi Dudum [c], Latha Palaniappan [c], Fatima Rodriguez [c,*]

[a] Department of Cardiovascular Medicine, Cleveland Clinic, Cleveland, OH, USA
[b] Center for Health Systems Research and Palo Alto Medical Foundation Research Institute, Sutter Health, Palo Alto, CA, USA
[c] Division of Cardiovascular Medicine and Cardiovascular Institute, Stanford University, Stanford, CA, USA

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ABSTRACT

Objective: There remain disparities by race and ethnicity in atherosclerotic cardiovascular disease (ASCVD). Statins reduce low-density lipoprotein cholesterol (LDL-c) and improve ASCVD outcomes. ASCVD treatment patterns across disaggregated race and ethnicity groups are incompletely understood. We aimed to evaluate statin use and LDL-c control for ASCVD by race and ethnicity.

Methods: From an electronic health record (EHR)-based cohort from a multisite Northern California health system, we included adults with an ASCVD diagnosis from 2010 to 2021 and at least 2 primary care visits, stratified by race and ethnicity (Non-Hispanic White [NHW], Non-Hispanic Black [Black], Hispanic, and Asian). Hispanic (Mexican, Puerto Rican, Other) and Asian (Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other) groups were disaggregated. Primary outcomes were 1-year post-ASCVD statin use (prescription) and LDL-c control (at least one value <70 mg/dL). Adjusted odds ratios (ORs) were estimated using logistic regression.

Results: Of 133,158 patients, there were 89,944 NHW, 6,294 Black, 12,478 (9.4 %) Hispanic and 13,179 (9.9 %) Asian patients. At 1 year after incident ASCVD, there was suboptimal statin use (any statins <60 %, high-intensity <25 %) and LDL-c control (<30 %) across groups, with lowest proportions in Black patients for statin use (46.7 %, any statin) and LDL-c control (10.7 %, OR 0.89 (0.81–0.97), referent NHW). Disaggregation of Asian and Hispanic groups unmasked within-group heterogeneity.

Conclusions: In patients with incident ASCVD, we describe suboptimal and heterogenous 1-year post-ASCVD guideline-directed statin use and 1-year post-ASCVD LDL-c control across disaggregated race and ethnicity groups. Findings may improve understanding of ASCVD treatment disparities and guide implementation.

1. Introduction

Statin therapy is a cornerstone of atherosclerotic cardiovascular disease (ASCVD) treatment through the reduction of low-density lipoprotein cholesterol (LDL-c) levels and cardiovascular events [1,2]. Yet, contemporary US data indicate that only about 50 % of patients with established ASCVD are using statins, with even fewer using guideline-directed high-intensity statins [3]. Statin nonuse is associated with worse mortality in ASCVD [4]. Understanding statin utilization patterns and gaps is crucial for implementation and public health efforts to improve ASCVD outcomes.

There are established disparities by race and ethnicity in ASCVD outcomes and treatment implementation [5,6]. Moreover, Hispanic and Asian populations have typically been studied in aggregate in epidemiologic and clinical research, but recent work has highlighted the importance of disaggregating Hispanic and Asian groups to unmask heterogeneity in cardiovascular health and risk including in dyslipidemia profiles and cause-specific mortality [7–16].

In the context of established ASCVD disparities by disaggregated race and ethnicity and the known importance of statin utilization as a

* Corresponding author at: Center for Academic Medicine, Department of Medicine/Division of Cardiovascular Medicine, Mail Code 5687, Stanford University School of Medicine, 453 Quarry Road, Palo Alto, CA 94304, USA.
E-mail address: frodrigu@stanford.edu (F. Rodriguez).
@FaRodriguezMD (F. Rodriguez)

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determinant of ASCVD outcomes, differential patterns of guideline-directed statin use for ASCVD across diverse, disaggregated race or ethnicity subgroups remain incompletely understood. Recent work regarding statin utilization by race and ethnicity in a nationally representative population disaggregated Hispanic participants into Mexican and Non-Mexican groups and did not disaggregate Asian subgroups [14]. Assessing statin use according to disaggregated race and ethnicity may help understand unmet ASCVD treatment opportunities. Findings may also highlight potential underlying structural biases leading to inequitable implementation of standard ASCVD treatment. To address this gap, we leveraged a contemporary, multiethnic electronic health record (EHR)-based cohort from Northern California with detailed disaggregated Hispanic and Asian data that have enabled the study of cardiovascular health differences by disaggregated subgroup [7-11,13]. In this cohort, we aimed to evaluate statin use patterns relating to an incident ASCVD diagnosis in diverse and disaggregated race and ethnicity groups.

2. Methods

2.1. Study design and cohort

For this retrospective cohort study, we identified adults aged 18 years or more with ASCVD diagnosed from January 2010 through December 2021 from electronic health records (EHRs) of a large community-based outpatient healthcare system in Northern California. ASCVD was defined by International Classification of Diseases (ICD)−9 and ICD-10 codes (Supplemental Table 1) for coronary artery disease, stroke, and peripheral vascular disease (excluding peripheral venous disease only). We applied a two-year wash-in period before the first ASCVD diagnosis ICD9/10 code appeared as the encounter diagnosis (denoted as the incident ASCVD diagnosis date) . The aim of the wash-in period was to ensure the absence of preceding ASCVD diagnoses. Within this two-year wash-in period, at least one encounter was required to ensure continued care in the system, with no evidence of an ASCVD diagnosis. To ensure continued care within the health system after the wash-in period, we required that patients have at least two visits on different dates with a primary care provider in the health system, with any EHR activity within one year before and one year after the first ASCVD diagnosis (Supplemental Figure 1).

2.2. Demographic and clinical variables

Demographic, clinical, and medication use data were extracted from the EHR. Baseline demographic data and clinical variables were extracted at the time of ASCVD diagnosis. Baseline laboratory values were represented as the most recent values recorded within 1 year prior to ASCVD diagnosis. Baseline comorbidities were assessed according to International Classification of Diseases (ICD)−9 or 10 codes documented in encounters within 1 year prior to the ASCVD diagnosis. Baseline statin use was defined as the most recent statin prescription at ASCVD diagnosis or within 1 year prior to diagnosis.

Race and ethnicity data were extracted from the EHR and Social Security database or otherwise inferred as previously described [17]. Major race and ethnicity categories were self-described as non-Hispanic White (NHW), non-Hispanic Black (Black), Hispanic, non-Hispanic Asian (Asian), or Other/Missing. Patients with Hispanic ethnicity were considered Hispanic regardless of race. For those non-Hispanic, if they reported more than 1 race, they were considered as Other. Hispanic patients (38.3 % White, 0.8 % Black, 2.5 % Asian, 53.9 % Other race) were disaggregated into Cuban, Mexican, Puerto Rican, or Other groups. Cuban patients were initially disaggregated but due to low sample size ($n = 89$) they were ultimately combined into the Other group. Asian patients were disaggregated into Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, or Other groups. If a patient reported more than 2 subgroups (for example, both Japanese and Korean), the patient was included in the Other group (Total $N = 96$).

2.3. Outcomes

The primary outcomes of this analysis were the proportion of statin use at 1 year after an incident ASCVD diagnosis and proportion with LDL cholesterol control (defined as at least one value < 70 mg/dL within 1 year) after an incident ASCVD diagnosis [2,18]. Statin use was assessed as the most recent documented statin prescription up to 1 year following the incident ASCVD diagnosis. Statin intensity was further classified according to ACC/AHA cholesterol treatment guidelines: (1) high intensity (daily dosage of atorvastatin 40–80 mg, rosuvastatin 20–40 mg, simvastatin 80 mg); (2) moderate intensity (daily dosage of atorvastatin 10 - <40 mg, fluvastatin 80 mg, lovastatin 40–60 mg, pitavastatin 2–4 mg, pravastatin 40–80 mg, rosuvastatin 5 - <20 mg, simvastatin 20–40 mg); and (3) low intensity (daily dosage of atorvastatin < 10 mg, rosuvastatin < 5 mg, fluvastatin < 80 mg, lovastatin < 40 mg, pravastatin < 40 mg, pitavastatin 1 mg, simvastatin < 20 mg) [2]. The overall statin use and statin use by intensity were recorded by each major race and/or ethnicity group and by disaggregated Hispanic and Asian subgroup.

Follow-up LDL cholesterol values up to 1 year after ASCVD diagnosis were extracted. LDL-c control was defined as at least one LDL cholesterol value < 70 mg/dL within 1 year after diagnosis.

2.4. Analysis

Data management and statistical analyses were conducted with SAS 9.2 (Cary, NC). Proportions were represented as percentages. For continuous variables, means and standard deviations were reported. Logistic regression models were applied to estimate the association between 1 year-statin use (any statin versus no statin, and moderate- or high-intensity statin versus no or low-intensity statin) and LDL-c control for major race and ethnicity groups, and in disaggregated Asian and Hispanic groups, respectively. Covariates included baseline characteristics (age, gender, baseline LDL-level (<70 mg/dL, ≥70 mg/dL, missing), smoking status, insurance, status, category of ASCVD, median household income, and baseline statin intensity). Covariates were selected by study investigators based on plausible clinical relevance to the outcomes of LDL-c control and statin utilization. Trends in statin use and LDL-c control were assessed over time (Supplementary data). This study was approved by the Institutional Review Board.

3. Results

Of 133,158 total patients with ASCVD, there were 89,944 NHW (67.5 %), 6294 Black (4.7 %), 12,478 (9.4 %) Hispanic and 13,179 (9.9 %) Asian patients (Table 1). NHW patients (mean age 70 +/- 13 years) were older, and there were more women in the Black group (59.9 %) compared with other groups at time of incident ASCVD diagnosis. Hispanic ASCVD patients had the highest prevalence of Type 2 diabetes mellitus (34.5 %) and the highest proportion of low-income households (below 25th percentile, 35 %). Black ASCVD patients had the highest prevalence of current smokers (12.8 %), obesity (44.9 %), and polyvascular disease (20 %), the highest average lipoprotein (a) levels (138 +/- 123 mg/dL), and the highest proportion with lipoprotein (a) > 50 mg/dl (57.1 %) within 1 year prior to the ASCVD diagnosis.

At baseline just prior to the incident ASCVD diagnosis, approximately two-thirds of patients did not have statin prescriptions (Fig. 1). One year after the incident ASCVD diagnosis, more than 40 % of patients did not have statin prescriptions across all groups, and less than a quarter were on high-intensity statins at 1 year. When stratified by race and ethnicity, Black patients had the highest proportion without statin prescriptions at year (53.3 %). Asian patients had the highest proportion of high-intensity statin use (22.6 %) at 1 year following the ASCVD diagnosis.

Table 1
Baseline patient characteristics across race and ethnicity groups.

Category N (%) unless otherwise specified	NHW *N* = 89,944	NH Black *N* = 6294	Hispanic *N* = 12,478	NH Asian *N* = 13,179	NH Other /Missing *N* = 11,263
Age (mean±SD), years	70.5 ± 12.8	65.1 ± 4.0	65.1 ± 14.9	66.5 ± 15	69.2 ± 14.6
Women	45,853 (51 %)	3773 (59.9 %)	6698 (53.7 %)	6279 (47.6 %)	5351 (47.5 %)
ASCVD Category					
Coronary artery disease	39,529 (43.9 %)	2242 (35.6 %)	5265 (42.2 %)	6571 (49.9 %)	5621 (49.9 %)
Stroke	23,759 (26.4 %)	1846 (29.3 %)	3500 (28 %)	3947 (29.9 %)	2879 (25.6 %)
Peripheral arterial disease	12,850 (14.3 %)	948 (15.1 %)	1773 (14.2 %)	1320 (10 %)	1726 (15.3 %)
Polyvascular	13,806 (15.3 %)	1258 (20 %)	1940 (15.5 %)	1341 (10.2 %)	1037 (9.2 %)
Hypertension	46,067 (51.2 %)	4081 (64.8 %)	6881 (55.1 %)	7036 (53.4 %)	5465 (48.5 %)
Type 2 Diabetes	16,302 (18.1 %)	2011 (32 %)	4308 (34.5 %)	3803 (28.9 %)	2685 (23.8 %)
Current Smoker	7464 (8.3 %)	806 (12.8 %)	834 (6.7 %)	522 (4 %)	955 (8.5 %)
Body mass index (mean ± SD), kg/m^2	28.7 ± 6.3	31.2 ± 7.7	30.4 ± 6.6	26.0 ± 4.8	28.6 ± 6.3
Underweight (<18.5)	1567 (1.7 %)	69 (1.1 %)	89 (0.7 %)	319 (2.4 %)	236 (2.1 %)
Normal (18.5 to <25)	22,680 (25.2 %)	1061 (16.9 %)	2104 (16.9 %)	5313 (40.3 %)	2824 (25.1 %)
Overweight (25 to <30)	29,566 (32.9 %)	1616 (25.7 %)	4021 (32.2 %)	4569 (34.7 %)	3704 (32.9 %)
Obese (30 or greater)	28,892 (32.1 %)	2824 (44.9 %)	5337 (42.8 %)	2029 (15.4 %)	3524 (31.3 %)
Missing	7239 (8 %)	724 (11.5 %)	927 (7.4 %)	949 (7.2 %)	975 (8.7 %)
Total cholesterol (mean±SD), mg/dL	181.2 ± 43.9	181.6 ± 44.4	178.2 ± 45.1	182.3 ± 43.1	181.0 ± 45.1
HDL cholesterol (mean±SD), mg/dL	54.4 ± 18.1	56.5 ± 18.0	50.1 ± 15.7	53.8 ± 16.6	52.0 ± 16.9
LDL cholestero[l] (mean±SD), mg/dL	101.7 ± 37.1	103.8 ± 38.0	99.2 ± 37.8	101.1 ± 36.9	102.5 ± 37.9
Triglycerides (mean±SD), mg/dL	129.2 ± 99.5	108.3 ± 88.1	148.6 ± 103.3	140.4 ± 108.3	136.1 ± 103.5
Had Lipoprotein (a)	364 (0.4 %)	14 (0.2 %)	34 (0.3 %)	90 (0.7 %)	36 (0.3 %)
Lipoprotein (a) (mean±SD), mg/dL	87.4 ± 99.2	137.6 ± 123.1	78.7 ± 104.2	64.2 ± 81.2	64.8 ± 62.5
Lipoprotein (a)>50 mg/dL among those with Lipoprotein (a) lab at baseline	172 (47.3 %)	8 (57.1 %)	15 (44.1 %)	33 (36.7 %)	15 (41.7 %)
Primary Insurance					
HMO or PPO/FFS	21,943 (24.4 %)	1744 (27.7 %)	4186 (33.5 %)	5364 (40.7 %)	3166 (28.1 %)
Medicaid/Medi-Cal	1206 (1.3 %)	307 (4.9 %)	446 (3.6 %)	327 (2.5 %)	236 (2.1 %)
Medicare FFS/HMO	51,320 (57.1 %)	3108 (49.4 %)	5989 (48 %)	6309 (47.9 %)	5381 (47.8 %)
Self/Other/Unknown	15,475 (17.2 %)	1135 (18 %)	1857 (14.9 %)	1179 (8.9 %)	2480 (22 %)
Median Household Income					
Below 25 % (<$55,443.04)	22,938 (25.5 %)	2131 (33.9 %)	4371 (35 %)	1461 (11.1 %)	2718 (24.1 %)
25–75 % ($55,443.04 – $89,016.80)	44,964 (50 %)	3322 (52.8 %)	6230 (49.9 %)	5512 (41.8 %)	5168 (45.9 %)
>75 % (>$89,016.80)	20,905 (23.2 %)	732 (11.6 %)	1732 (13.9 %)	6101 (46.3 %)	3197 (28.4 %)
Missing	1137 (1.3 %)	109 (1.7 %)	145 (1.2 %)	105 (0.8 %)	180 (1.6 %)

Abbreviations. ASCVD, atherosclerotic cardiovascular disease; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NH, non-Hispanic; NHW, non-Hispanic White; SD, standard deviation.
P-values for all comparisons are <0.05.

Less than one-fifth of patients across all groups had at least one LDL-c value reaching the guideline-directed goal under 70 mg/dL (Table 2). Black patients had the lowest overall proportion of 1-year LDL-c control (11.8 %). Compared with NHW patients, Black patients had lower adjusted odds of achieving LDL-c control at 1 year, while Asian patients had higher overall odds (Table 5).

3.1. *Disaggregated Hispanic and Asian groups*

3.1.1. *Hispanic patients*

Among Hispanic groups, Puerto Rican ASCVD patients had the highest prevalence of smoking (11.8 %), while Mexican ASCVD patients had the highest prevalence of diabetes (38 %) (Table 3). At baseline, approximately two-thirds of Hispanic patients were not on any statin therapy prior to ASCVD diagnosis (Fig. 2).

At 1 year after an ASCVD diagnosis, nearly half of all Hispanic patients were not on any statin therapy (Mexican 46.9 %, Puerto Rican 47.8 %, Other Hispanic 49.9 % (Fig. 2). Less than one-fifth were on high intensity statin therapy (Mexican 15.5 %, Puerto Rican 15.1 %, Other Hispanic 16 %). A little over a half of patients had a follow-up LDL-c level checked within one year of an ASCVD event, and approximately one-fifth or fewer had a documented LDL value meeting the guideline-directed goal of under 70 mg/dL with Puerto Ricans experiencing the lowest proportion of LDL-c control (16.2 %) (Table 4). Among Hispanic patients, Puerto Rican patients had lower odds of achieving LDL-c control at 1 year compared with Mexican patients (Table 5).

3.1.2. *Asian patients*

Among Asian groups, Asian Indian patients were the youngest at time of ASCVD diagnosis (60.3 +/- 14.1 years) and had the lowest average high-density lipoprotein (HDL) cholesterol value (49 mg/dL). Nearly a third of Asian Indian patients with ASCVD had diabetes and 21 % were obese (Table 3). Filipino patients were more likely to be active smokers among Asian subgroups (6.1 %). Approximately two-thirds of patients were not on statin therapy prior to the ASCVD event across Asian categories (Fig. 2).

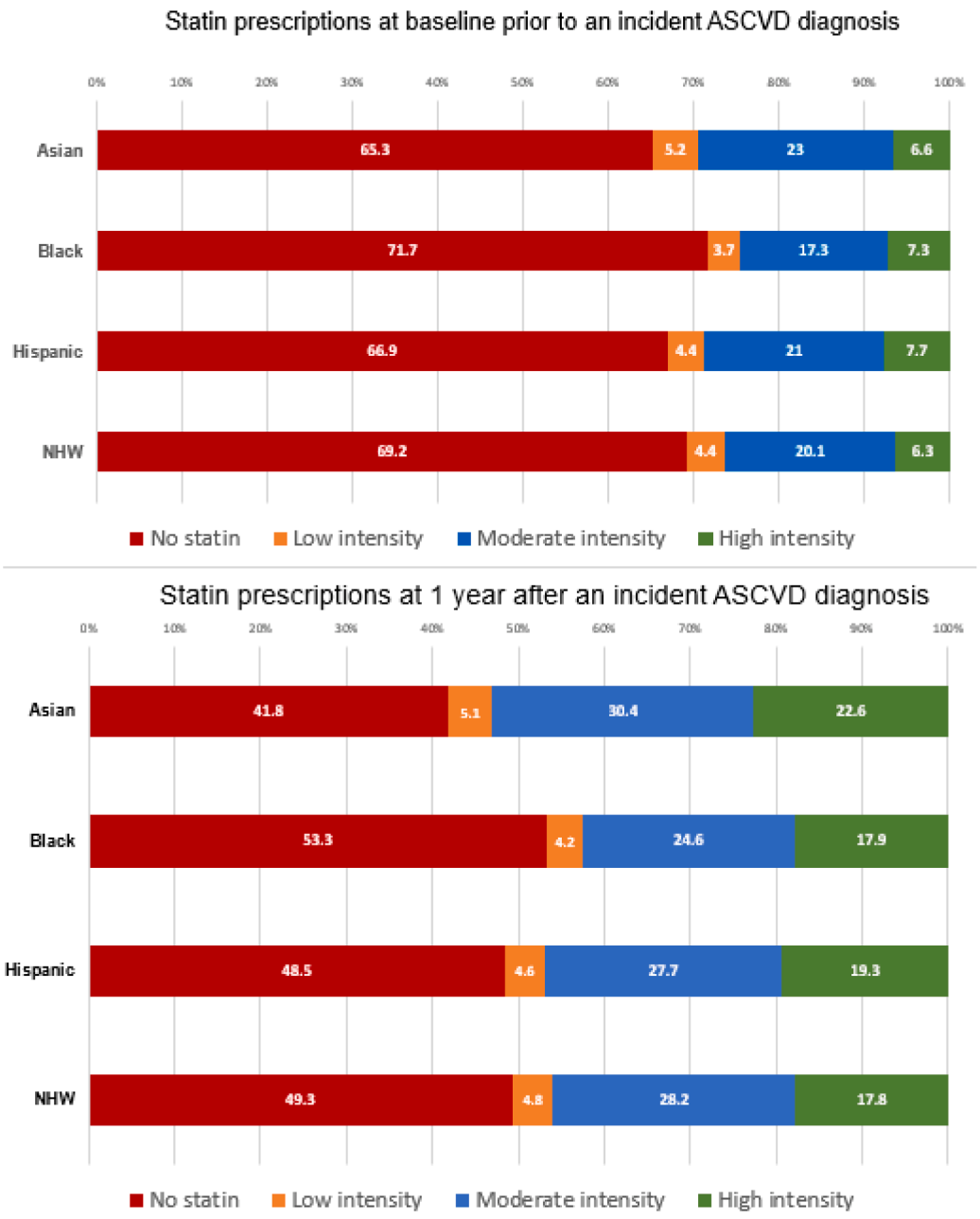


Fig. 1. Statin prescriptions at baseline and 1 year after an incident ASCVD diagnosis by race and ethnicity groups.
Abbreviations. ASCVD, atherosclerotic cardiovascular disease. P-values for comparisons are <0.05.

At 1 year after the ASCVD diagnosis, approximately 38 % to 47 % were not on statin therapy across Asian subgroups (Asian Indian 38.1 %, Chinese 42.3 %, Filipino 40.7 %, Japanese 43.3 %, Korean 43.8 %, Vietnamese 39.2 %, other Asian 46.6 %, Fig. 2, Table 4). Only approximately one-quarter to one-fifth of patients were on high intensity statin therapy across Asian subgroups, with Japanese patients exhibiting the lowest proportion of high-intensity statins and Vietnamese patients exhibiting the highest proportion of high-intensity statin use (Asian Indian 26.5 %, Chinese 20 %, Filipino 25.4 %, Japanese 17.7 %, Korean 23.7 %, Vietnamese 27.7 %, Other Asian 21.3 %). Among patients with follow-up LDL values checked within 1 year of ASCVD diagnosis (62 %), approximately a quarter or fewer patients had a documented LDL-c value meeting the guideline-directed goal of under 70 mg/dL across Asian subgroups (Table 4).

4. Discussion

Leveraging a contemporary EHR-based cohort enriched for diverse racial and ethnic representation, we describe real-world patterns and gaps in guideline-directed statin use and LDL-c goal attainment following an incident ASCVD diagnosis (Central Illustration). We identified several findings: 1) Key differences in baseline risk profiles across race and ethnicity groups that can inform primary prevention strategies, including lower age at incident ASCVD in non-White groups, higher proportions of women with incident ASCVD, and of polyvascular disease and obesity in Black patients; and higher proportion with type 2 diabetes in Hispanic patients; 2) Suboptimal and variable 1-year guideline-directed statin use and LDL-c control after incident ASCVD across major race and ethnicity groups, with the lowest statin use and LDL-c control in Black patients; and 3) Within-group heterogeneity in 1-year guideline-directed statin use and LDL-c control after incident ASCVD

Table 2
Low-density lipoprotein cholesterol levels relating to incident ASCVD diagnosis by major race and/or ethnicity group.

Category N (%) unless otherwise specified	NHW *N* = 89,944	NH Black *N* = 6294	All Hispanic *N* = 12,478	NH Asian *N* = 13,179	NH—Other /Missing *N* = 11,263
LDL-c measured within 1 year after ASCVD diagnosis	50,991 (56.7 %)	2891 (45.9 %)	6942 (55.6 %)	8170 (62 %)	6424 (57 %)
LDL-c at 1 year, (mean, SD), mg/dL	89.7 ± 35.2	94.4 ± 37.3	88.5 ± 36.3	83.5 ± 34.7	88.6 ± 36.4
At least one LDL-*c* < 70 mg/dL	15,883 (17.7 %)	743 (11.8 %)	2337 (18.7 %)	3179 (24.1 %)	2156 (19.1 %)

Abbreviations. ASCVD, atherosclerotic cardiovascular disease; LDL, low-density lipoprotein; NH, non-Hispanic; NHW, non-Hispanic White; PDC, proportion of days covered; SD, standard deviation.
P-values for all comparisons are <0.05.

in disaggregated Asian and Hispanic groups. These data may guide tailored strategies to improve ASCVD prevention and treatment across diverse race and ethnicity groups including in fast-growing Hispanic and Asian populations that can have greater within-group than between-group differences in ASCVD risk and outcomes.

Data from the Chest Pain-MI Registry™ reported statin use rates greater than 90 % at discharge after ST-segment elevation and non-ST-segment elevation myocardial infarctions from 2010 through 2021, as noted in the Heart Disease and Stroke Statistics 2023 update from the American Heart Association [19]. Our data suggest lower real-world statin use at 1 year after an incident ASCVD diagnosis and match prior observational data around statin use in secondary prevention [3]. These differences may be related to several factors including 1) inclusion of comprehensive ASCVD diagnoses in the present study including ischemic heart disease without MI cerebrovascular disease, and peripheral arterial disease, and 2) assessment of statin prescriptions at 1 year after an incident diagnosis – thus, potentially accounting for clinical inertia in outpatient settings, discontinuation, and lack of persistence – as compared with in-hospital statin prescriptions rates after a coronary event which may demonstrate higher statin prescription rates

Table 3
Baseline patient characteristics by disaggregated Hispanic and Asian subgroups.

Category N (%) unless otherwise specified	Hispanic			NH-Asian						
	Mexican *N* = 5701	**Puerto Rican *N* = 272**	**Other Hispanic *N* = 6505**	**Asian Indian *N* = 2816**	**Chinese *N* = 3809**	**Filipino *N* = 2490**	**Japanese *N* = 1364**	**Korean *N* = 284**	**Vietnamese *N* = 314**	**Other Asian *N* = 2122**
Age (mean±SD)	64.5 ± 15.1	65.2 ± 13.4	65.5 ± 14.7	60.3 ± 14.1	70.0 ± 14.0	64.6 ± 14.5	75.0 ± 13.1	64.8 ± 15.1	63.9 ± 14.5	65.6 ± 15.6
Women	2965 (52.0 %)	156 (57.4 %)	3577 (55.0 %)	1832 (65.1 %)	1989 (52.2 %)	1141 (45.8 %)	565 (41.4 %)	135 (47.5 %)	167 (53.2 %)	1079 (50.8 %)
English	4006 (70.3 %)	247 (90.8 %)	5166 (79.4 %)	2352 (83.5 %)	2490 (65.4 %)	2196 (88.2 %)	1269 (93 %)	193 (68 %)	191 (60.8 %)	1643 (77.4 %)
ASCVD Category										
Coronary artery disease	2388 (41.9 %)	109 (40.1 %)	2768 (42.6 %)	1776 (63.1 %)	1811 (47.5 %)	1200 (48.2 %)	511 (37.5 %)	123 (43.3 %)	148 (47.1 %)	1012 (47.7 %)
Stroke	1622 (28.5 %)	84 (30.9 %)	1794 (27.6 %)	554 (19.7 %)	1284 (33.7 %)	744 (29.9 %)	477 (35 %)	106 (37.3 %)	124 (39.5 %)	663 (31.2 %)
Peripheral artery disease	862 (15.1 %)	31 (11.4 %)	880 (13.5 %)	244 (8.7 %)	423 (11.1 %)	224 (9 %)	194 (14.2 %)	25 (8.8 %)	24 (7.6 %)	189 (8.9 %)
Polyvascular disease	829 (14.5 %)	48 (17.6 %)	1063 (16.3 %)	242 (8.6 %)	291 (7.6 %)	322 (12.9 %)	182 (13.3 %)	30 (10.6 %)	18 (5.7 %)	258 (12.2 %)
Hypertension	3238 (56.8 %)	140 (51.5 %)	3503 (53.9 %)	1261 (44.8 %)	2029 (53.3 %)	1557 (62.5 %)	835 (61.2 %)	126 (44.4 %)	157 (50 %)	1080 (50.9 %)
Type 2 Diabetes	2168 (38 %)	94 (34.6 %)	2046 (31.5 %)	897 (31.9 %)	904 (23.7 %)	922 (37 %)	354 (26 %)	85 (29.9 %)	81 (25.8 %)	563 (26.5 %)
Body mass index (kg/m2 mean±SD)	30.7 ± 6.3	30.5 ± 6.5	30.2 ± 6.7	27.1 ± 4.8	24.8 ± 4	27±5	25.5 ± 5.2	25.5 ± 4.5	24.7 ± 3.7	26.3 ± 5.0
Underweight (<18.5)	37 (0.6 %)	0 (0 %)	52 (0.8 %)	24 (0.9 %)	113 (3 %)	42 (1.7 %)	76 (5.6 %)	9 (3.2 %)	7 (2.2 %)	48 (2.3 %)
Normal (18.5 to <25)	896 (15.7 %)	44 (16.2 %)	1164 (17.9 %)	936 (33.2 %)	1873 (49.2 %)	816 (32.8 %)	592 (43.4 %)	116 (40.8 %)	167 (53.2 %)	820 (38.6 %)
Overweight (25 to <30)	1831 (32.1 %)	81 (29.8 %)	2109 (32.4 %)	1116 (39.6 %)	1257 (33 %)	897 (36 %)	399 (29.3 %)	101 (35.6 %)	105 (33.4 %)	697 (32.8 %)
Obese (30 or greater)	2648 (46.4 %)	123 (45.2 %)	2566 (39.4 %)	579 (20.6 %)	308 (8.1 %)	520 (20.9 %)	207 (15.2 %)	36 (12.7 %)	20 (6.4 %)	365 (17.2 %)
Missing	289 (5.1 %)	24 (8.8 %)	614 (9.4 %)	161 (5.7 %)	258 (6.8 %)	215 (8.6 %)	90 (6.6 %)	22 (7.7 %)	15 (4.8 %)	192 (9.0 %)
Total cholesterol (mean ±SD), mg/dL	176.0 ± 44.7	182.7 ± 45.9	180.1 ± 45.3	180.4 ± 43.1	182.2 ± 40.3	181.1 ± 46.8	185±42.6	186.9 ± 42	186.1 ± 40.6	183.7 ± 44.6
HDL cholesterol (mean ±SD), mg/dL	49.0 ± 15.1	51.8 ± 16.7	51.2 ± 16.2	49±14.1	56.3 ± 17	53.3 ± 16.2	59.7 ± 18.6	54.9 ± 16.9	53.4 ± 15.6	52.7 ± 16.1
LDL cholesterol (mean ±SD), mg/dL	97.6 ± 37.2	103.7 ± 40.6	100.6 ± 38.3	104.4 ± 37.3	100±34.7	98.9 ± 38.7	97.8 ± 35.3	104.7 ± 38.7	103.3 ± 35.8	102.5 ± 38.9
Triglycerides (mean ±SD), mg/dL	151.6 ± 109.0	139.0 ± 94.1	145.9 ± 97.7	136.8 ± 82.8	132.3 ± 93.6	148.8 ± 140.2	139.1 ± 93.1	143±85	149.5 ± 81.4	150.8 ± 137.2
Lipoprotein (a) (mean ±SD), mg/dL	89.7 ± 160.9	48	74.6 ± 67.9	70.5 ± 76	84.3 ± 127.6	79.4 ± 108.7	15±10.4	33±28.3	–	44.6 ± 58.7
Current smoker	383 (6.7 %)	32 (11.8 %)	419 (6.4 %)	110 (3.9 %)	91 (2.4 %)	153 (6.1 %)	39 (2.9 %)	14 (4.9 %)	10 (3.2 %)	106 (5 %)

Abbreviations. ASCVD, atherosclerotic cardiovascular disease; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NH, non-Hispanic; NHW, non-Hispanic White; SD, standard deviation.
P-values for all comparisons are <0.05.

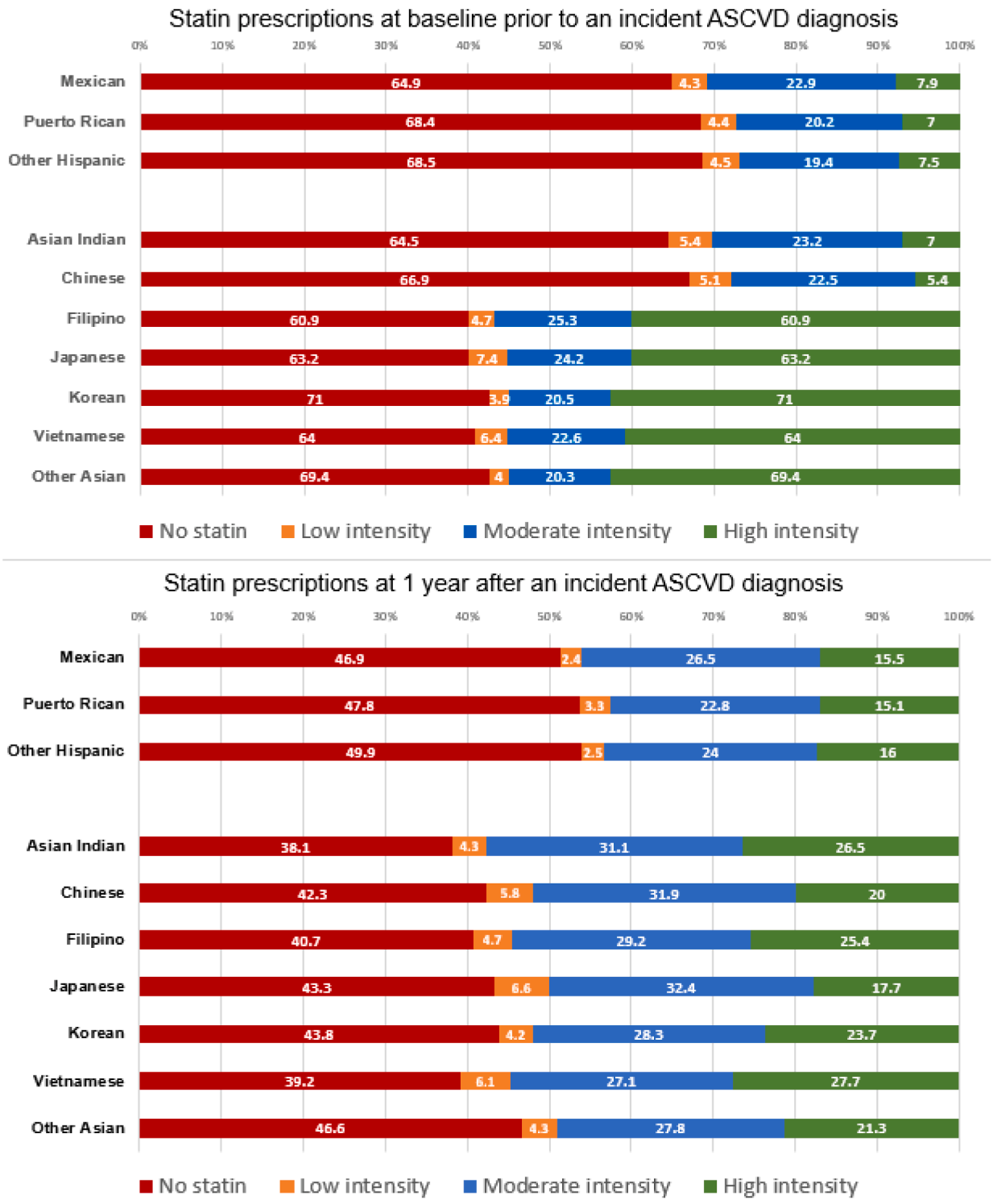


Fig. 2. Statin prescriptions at baseline and 1 year after an incident ASCVD diagnosis by disaggregated Hispanic and Asian subgroups.
Abbreviations. ASCVD, atherosclerotic cardiovascular disease. P-values for comparisons are <0.05.

due to standardized care pathways.

Our findings match and extend prior work around suboptimal statin use by race and ethnicity for ASCVD. We found that Black patients had the lowest level of guideline-directed statin use and LDL-c control at 1 year after an incident ASCVD diagnosis as compared with NHW, Hispanic, and Asian groups. Findings are similar to those from the Patient and Provider Assessment of Lipid Management (PALM) registry in which Black individuals were less likely to receive guideline-directed statin prescriptions [5]. We observed higher female representation in Black patients with incident ASCVD, suggesting additive disparities at the intersection of sex and race [6]. Similar findings from SWAN (the study of women's health across the nation) suggested that statin use was approximately 50 % in women with established cardiovascular disease, with lower odds of statin use in Black women as compared with White women [20]. A higher proportion of Black patients with polyvascular disease may further suggest more widespread ASCVD at presentation.

Table 4
Low-density lipoprotein cholesterol control relating to incident ASCVD diagnosis by disaggregated Hispanic and Asian subgroups.

Category N (%) unless otherwise specified	Hispanic			NH-Asian						
	Mexican $N = 5701$	Puerto Rican $N = 272$	Other Hispanic $N = 6505$	Asian Indian $N = 2816$	Chinese $N = 3809$	Filipino $N = 2490$	Japanese $N = 1364$	Korean $N = 284$	Vietnamese $N = 314$	Other Asian $N = 2122$
LDL cholesterol measured within 1 year after diagnosis	3376 (59.2 %)	162 (59.6 %)	3404 (52.3 %)	1924 (68.3 %)	2436 (64 %)	1447 (58.1 %)	836 (61.3 %)	176 (62 %)	205 (65.3 %)	1159 (54.6 %)
LDL cholesterol at 1 year, (mean, SD), mg/dL	87.5 ± 36	89.9 ± 34.2	89.4 ± 36.6	82.4 ± 35.0	82.8 ± 33.0	83.8 ± 35.4	84.1 ± 33.8	87.4 ± 39.0	86.3 ± 36.9	85.0 ± 36.0
At least one LDL cholesterol value <70 mg/dL	1188 (20.8 %)	44 (16.2 %)	1105 (17 %)	785 (27.9 %)	947 (24.9 %)	559 (22.4 %)	307 (22.5 %)	66 (23.2 %)	71 (22.6 %)	449 (21.2 %)

Abbreviations. ASCVD, atherosclerotic cardiovascular disease; LDL, low-density lipoprotein; NH, non-Hispanic; PDC, proportion of days covered; SD, standard deviation.

Table 5
Odds ratio for statins use and LDL-c control at 1 year-post ASCVD by race/ethnicity, from logistic regression controlling baseline age, gender, race/ethnicity, baseline LDL-level (<70, ≥70), smoking status, baseline statin intensity, median household income, insurance, category of ASCVD. $N = 133{,}158$.

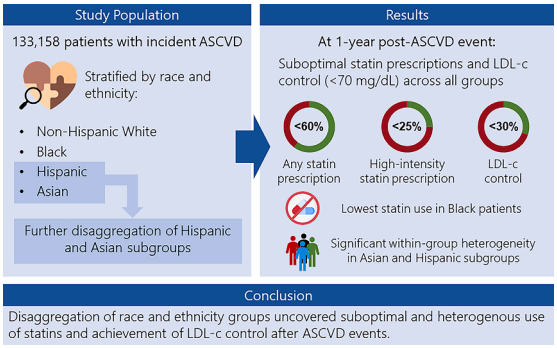
Race or ethnicity category OR (95 % CI)	Moderate/high intensity statins vs. low intensity or no statins $N = 133{,}158$	Any Statin vs. No Statin $N = 133{,}158$	LDL-c under control at 1 year vs LDL-c not under control $N = 75{,}418$
All Asian[a]	**1.27 (1.22, 1.33)**	**1.29 (1.24, 1.35)**	**1.38 (1.31, 1.46)**
Asian Indian[b]	**1.13 (1.01, 1.26)**	1.09 (0.97,1.21)	1.10 (0.96, 1.25)
Chinese[b]	Referent[2]	Referent[2]	Reference[2]
Filipino[b]	1.07 (0.96, 1.20)	1.05 (0.93,1.18)	1.01 (0.88, 1.17)
Japanese[b]	1.02 (0.89, 1.18)	0.98 (0.85,1.13)	0.93 (0.78, 1.11)
Korean[b]	1.12 (0.86, 1.47)	1.08 (0.83,1.42)	1.05 (0.75, 1.47)
Vietnamese[b]	1.16 (0.89, 1.50)	1.16 (0.89,1.51)	0.84 (0.61, 1.16)
Other Asian[b]	0.95 (0.84, 1.07)	0.91 (0.81,1.03)	1.04 (0.89, 1.21)
All Hispanic[a]	1.02 (0.98, 1.06)	1.02 (0.98, 1.07)	**1.16 (1.10, 1.23)**
Mexican[b]	Referent[2]	Referent[2]	Referent[2]
Puerto Rican[b]	0.99 (0.75, 1.30)	1.02 (0.78, 1.35)	**0.68 (0.47, 0.997)**
Other Hispanic[b]	0.97 (0.90, 1.06)	0.95 (0.88, 1.03)	**0.86 (0.78, 0.96)**
Black[a]	0.95 (0.90, 1.01)	0.95 (0.90, 1.01)	**0.89 (0.81, 0.97)**

[a] Race or ethnicity categories include Hispanic, White, Black, Asian, and Non-Hispanic Other. White is the reference level.

[b] Race or ethnicity categories include Hispanic subgroups, White, Black, Asian subgroups, and Non-Hispanic Other. Chinese is the reference group among Asian group, and Mexican is the reference group among Hispanic group.

These represent concerning epidemiologic findings that may be relevant to persistent ASCVD disparities [6]. Interventions that target prevention across the life course, including primordial and primary prevention and subsequent improved ASCVD treatment implementation are warranted to mitigate such disparities.

Disaggregation of Hispanic patients showed that individuals of Puerto Rican descent were less likely to have LDL-c control across Hispanic subgroups. This is consistent with data that have documented greater years of potential life lost from cardiovascular disease mortality for Puerto Rican individuals as compared with Mexican patients and highlights the importance of disaggregation [21]. Prior studies of Hispanic health have invoked the Hispanic paradox, which denotes an



Central Illustration. Abbreviations. ASCVD, atherosclerotic cardiovascular disease; LDL-c, low-density lipoprotein cholesterol.

epidemiologic finding of lower mortality in Hispanic versus NHW populations with generally more adverse socioeconomic conditions [22]., [23] Recent national data suggest that the due to differential burden of the COVID-19 pandemic, this often-quoted Hispanic mortality advantage has narrowed, and on a county-level, it has reversed in several locations across the US [24]. Data also suggest worsening burden of cardiovascular disease among Hispanic groups since the COVID-19 pandemic [25]. Thus, there is a need for public health strategies to correct the adverse post-COVID-19 trajectory of cardiovascular outcomes among Hispanic populations. Better statin implementation for ASCVD may represent a potential strategy to mitigate concerns around widening post-pandemic health and cardiovascular disparities in Hispanic populations.

We observed that non-White groups were younger at time of incident ASCVD as compared with NHW patients, suggesting the need to close early life preventive gaps. Within Asian subgroups, Asian Indians were generally younger at time of ASCVD diagnosis with worse cardiometabolic markers such as lower HDL cholesterol values and higher diabetes and obesity prevalence, suggesting the importance of focusing on improve early life cardiometabolic health in Asian Indian patients given their elevated risk for ASCVD-related mortality and hospitalization as compared with NHW patients [26].

Although Asian patients had higher statin use and LDL-c control as compared with NHW patients, disaggregation indicated that Japanese patients were less like to be prescribed high-intensity statins as compared with other Asian subgroups. Observed differences in statin prescriptions by subgroups may reflect historical concerns for different drug metabolism and pharmacokinetics in Asian patient groups, for instance, with high intensity statins [2]. However, contemporary clinical trial of high-dose versus low-dose pitavastatin in Japanese patients demonstrated that higher dose therapy led to lower LDL cholesterol and improved secondary prevention [27]. Reasons for statin nonuse can vary across groups and may include diverse clinician, patient, and system

factors. Novel efforts are warranted to understand reasons for statin nonuse. Recent work using deep learning of unstructured EHR clinical notes provided insight into differences in reasons for statin nonuse by race and ethnicity [28].

4.1. Limitations

A primary strength of our study is the use of a large, well-curated EHR database that allows detailed characterization of disaggregated Hispanic and Asian subgroups who have typically been understudied and underrepresented. Our results should, however, be interpreted in the setting of certain limitations. The patients in the study may not be generalizable across the US given a largely insured population from Northern California. Our retrospective study design that relies on diagnosis codes and medication prescription data may have inherent limitations due to the use of systems built for clinical care. For example, care fragmentation or loss of follow-up within the health system may lead to non-captured events or incomplete medication documentation. We aimed to mitigate this limitation by ensuring ongoing health system use and participation through at least 2 visits with primary care and EHR activity 1 year before and after the ASCVD diagnosis. Competing fatal events that occurred prior to the study period of January 2010 through December 2021 may have been missed. Missing data precluded the inclusion of lipoprotein (a) levels in logistic regression models. Race and ethnicity were self-reported or inferred using validated methods [17]. Disaggregation of the "Other" Hispanic and Asian groups through larger, dedicated cohorts may further unmask differences in additional subgroups such as Cuban patients who were not well-represented in our cohort. We did not have data around statin intolerance or side effects which may affect statin prescription decisions. Efforts to assess reasons for statin nonuse may require novel analytic methods which we previously demonstrated in an analysis using deep learning of electronic health records. For this study, we did not assess interval trajectories or changes in statin prescriptions given our focus on the overall guideline directed statin prescription patterns at 1 year after incident ASCVD diagnosis. Assessing the statin prescription "journey" that leads to overall suboptimal statin prescriptions at 1 year – in conjunction with analyses of reasons for statin nonuse– may provide further insights into these findings. Future work should further evaluate determinants of statin prescription, LDL-C measurements, and LDL-C control in diverse populations by incorporating additional social variables such as language preference or zip code that were not included in the present study.

5. Conclusions

In conclusion, in an EHR-based cohort from a health system in Northern California, we identify suboptimal and heterogenous patterns of guideline-directed statin use and LDL-c control following an incident ASCVD diagnosis in diverse, disaggregated race and ethnicity groups. Characterizing these differential treatment gaps may inform tailored implementation strategies to prevent, treat, and mitigate disparities in ASCVD.

Data availability

The dataset analyzed during the current study is not publicly available due to reasonable privacy and security concerns. The underlying EHR data are not easily redistributable to researchers other than those engaged in the Institutional Review Board-approved research collaborations in the current project. The corresponding author may be contacted for access to EHR data for an IRB-approved collaboration.

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Author declaration

We wish to draw the attention of the Editor to the following facts which may be considered as potential conflicts of interest and to significant financial contributions to this work: FR reports consulting relationships with Healthpals, Novartis, NovoNordisk (CEC), Esperion, Movano Health, and Kento Health outside the submitted work. The remaining authors report no relevant disclosures or competing interests.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

CRediT authorship contribution statement

Ashish Sarraju: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Xiaowei Yan:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing. **Qiwen Huang:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing. **Ramzi Dudum:** Conceptualization, Investigation, Methodology, Writing – review & editing. **Latha Palaniappan:** Writing – review & editing. **Fatima Rodriguez:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2024.100647.

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